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# Journal of Human Nutrition and Dietetics

The Official Journal of the British Dietetic Association

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# The impact of branched-chain amino acid supplementation on measures of glucose homeostasis in individuals with hepatic disorders: A systematic review of clinical studies

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## Abstract

**Background:** Branched chain amino acid (BCAA) supplementation may influence glucose metabolism in individuals with an impaired glycaemic profile. This systematic review investigated the effects of isolated BCAA supplementation on measures of glucose homeostasis in individuals with hepatic disorders.

**Methods:** We searched PubMed, Web of Science, Cochrane Library and Scopus for published clinical trials that investigated the effects of isolated BCAA supplementation on measures of glucose homeostasis, including serum glucose and insulin, glycated haemoglobin (HbA1c) levels and homeostatic model assessment for insulin resistance (HOMA-IR) scores.

**Results:** Eleven trials met the inclusion criteria. Only one study revealed a decrease in serum glucose from BCAA supplementation compared to three studies that showed increases. Five studies demonstrated no significant changes in serum glucose, and two studies displayed no changes in HbA1c following BCAA supplementation. Serum levels of insulin were decreased in three studies, remained unchanged in one, and increased in the remaining three studies. BCAA supplementation reduced HOMA-IR scores in two studies, increased HOMA-IR scores in another two, or resulted in no changes in two other studies.

**Conclusions:** BCAA supplementation in isolation had no effect on overall glucose homeostasis in individuals with hepatic disorders, although some improvements on serum insulin levels and HOMA-IR scores were observed. Overall, there is little evidence to support the utilisation of BCAA supplementation as a potential nutritional strategy for improving measures of glucose homeostasis in individuals with hepatic disorders.

## KEYWORDS

BCAA, branched chain amino acids, hepatic disorders, liver disease, nutritional supplementation

## Key points

- Hepatic disorders such as liver cirrhosis, hepatic encephalopathy and hepatocellular carcinoma are characterised by an impaired circulating branched-chain amino acid (BCAA) profile.

- The aim of this systematic review was to explore the effects of isolated BCAA supplementation on markers of glucose metabolism in adults with hepatic disorders.
- Qualitative analysis revealed limited benefits of isolated BCAA supplementation on overall glucose homeostasis among individuals with hepatic disorders.
- BCAA supplementation as an independent strategy is not an effective tool in improving glucose homeostasis in this population group.

## INTRODUCTION

Branched-chain amino acids (BCAAs; leucine, isoleucine, valine) are essential amino acids metabolised primarily in skeletal muscle.<sup>1</sup> Despite their prominent role in skeletal muscle protein metabolism, BCAAs are fractionally catabolised in other organs, including the liver and adipose tissue,<sup>2</sup> contributing to the upregulation of glucose transport and insulin secretion.<sup>3</sup> However, excessive BCAA consumption interferes with lipid oxidation in skeletal muscle,<sup>4</sup> leading to impaired insulin signalling.<sup>3,5–7</sup> Conversely, impaired insulin signalling may cause exacerbated skeletal muscle, adipose tissue and liver proteolysis,<sup>8–10</sup> which could potentially lead to high circulating levels of BCAAs.<sup>11</sup> Epidemiological evidence has proposed that insulin resistance (IR) may drive increased circulating fasting BCAA levels, as opposed to BCAA consumption being the primary driver of IR.<sup>12</sup> Indeed, a recent systematic review of observational studies has reported conflicting results on the association between intake of BCAAs and IR development, with two of the three reported studies suggesting a proportional relationship.<sup>13</sup>

BCAA supplementation has been reported to increase insulin secretion but with minimal influence on glycaemic responses,<sup>14,15</sup> as opposed to protein supplements such as whey protein, which may modulate glucose disposal in an insulin-dependent manner.<sup>14,16–18</sup> Particularly, an improved oral glucose sensitivity index and postprandial insulin secretion have been observed in humans following short (1 week)<sup>19</sup> and longer (4 and 8 weeks)<sup>20,21</sup> dietary BCAA intake restriction; however, longer trials may be warranted to elicit more clinically meaningful findings.

Hepatic disorders such as liver cirrhosis, hepatic encephalopathy and hepatocellular carcinoma are all characterised by decreased circulating BCAA levels.<sup>22</sup> Hepatic disorders have long been linked with impaired glucose tolerance and IR, which has more recently been observed to improve upon BCAA supplementation.<sup>23–26</sup> Indeed, BCAAs may increase peroxisome proliferator-activated receptor- $\gamma$  and uncoupling protein (UCP)2 in the liver and UCP3 in skeletal muscle, stimulating free fatty acid oxidation and improving insulin sensitivity.<sup>22</sup> The effects of BCAA consumption on glycaemic profile may depend on dose, duration and individual health

status. These observations of improved IR and glucose tolerance with BCAA supplementation contrast considerably with the association of elevated serum BCAAs with IR in some chronic diseases. The aim of this systematic review was to investigate the effects of isolated BCAA supplementation on markers of glucose metabolism in adults with various hepatic disorders.

## METHODS

This systematic review was performed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)<sup>27</sup> guidelines and the protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (Registration number: CRD42022304636).

### Search strategy

Two independent reviewers (KP and RK) searched PubMed, Scopus, Web of Science and Cochrane Library, using the following search terms: “BCAA” OR “branched chain amino acids” OR “leucine” AND “insulin” OR “blood glucose” OR “glycaemic” OR “blood sugar” OR “HbA1c” OR “HOMA-IR” AND “liver disease” OR “hepatic disorder” OR “cirrhosis” OR “hepatitis” OR “hepatocellular carcinoma” OR “portal vein embolisation” OR “hepatic encephalopathy”. The full search strategy and search terms used are described in the Supporting information (Table S1). Discrepancies in the literature search process were resolved by a third and fourth investigator (PG and KKT).

### Study eligibility

Studies were included based on the following inclusion criteria: (1) human studies in populations with hepatic disorders; (2) clinical trials; (3) BCAAs as an intervention group; and (4) oral route of administration. Studies were excluded based on the following exclusion criteria: (1) non-clinical trials; (2) BCAA co-ingestion with a mixed meal; (3) acute studies lasting < 7 days; and (4) full text not published.



## Data extraction and risk of bias

Two reviewers (KP and RPK) extracted data based on name of first author, publication date, country of origin, study design, participant health status, age, sex, sample size, outcome measures, supplemental form, dose and duration. Disagreements between reviewers were resolved by a third and fourth investigator (PG and KSK). The quality of included studies was assessed using the Cochrane Risk-of-Bias 2 (RoB2) for randomised trials tool and evaluated by three independent reviewers (KP, PG and KKT). Appraisal of risk of bias using the RoB2 tool included assessment of the domains of bias in randomised controlled trials (RCTs): (1) randomisation process; (2) deviations from intended interventions; (3) missing outcome data; (4) measurement of the outcome; and (5) selection of the reported result.<sup>28</sup> According to the RoB2 tool scoring system, study quality was defined as low risk of bias, some concerns or high risk of bias. In addition, risk of bias assessment for the non-randomised (single arm) trials was performed using the Risk Of Bias In Non-Randomised Studies—of Interventions (ROBINS-I) tool that classifies studies based on bias due to: (1) confounding factors; (2) selection of participants into the study; (3) the classification of interventions; (4) deviations from intended interventions; (5) missing data; (6) outcome measurements; and (7) selection of the reported result.<sup>29</sup> According to ROBINS-I tool, the quality of studies was categorised as low, moderate or serious risk.

## RESULTS

### Search results

The literature search yielded 3403 publications. In total, 1318 duplicates were excluded, and 2085 publications were sought for retrieval. Following screening of titles, abstracts and full texts, 20 studies were retrieved examining the effects of BCAA supplementation on markers of glucose metabolism. Of these, two studies had ineligible interventions, three had incompatible study population and four had missing data. Overall, 11 studies were deemed eligible for inclusion in the review (Figure 1).

### Characteristics of the included studies

All relevant information pertained to participant characteristics are summarised in Table 1. Of the 11 studies, seven studies were conducted in Japan,<sup>30–36</sup> two in Mexico,<sup>38,39</sup> one in Italy<sup>37</sup> and one in Spain.<sup>40</sup> Two studies were conducted in individuals aged between 50 and 60 years<sup>32,39</sup> and nine in individuals  $\geq 60$  years.<sup>30,31,33–38,40</sup> All studies were cohorts of both males

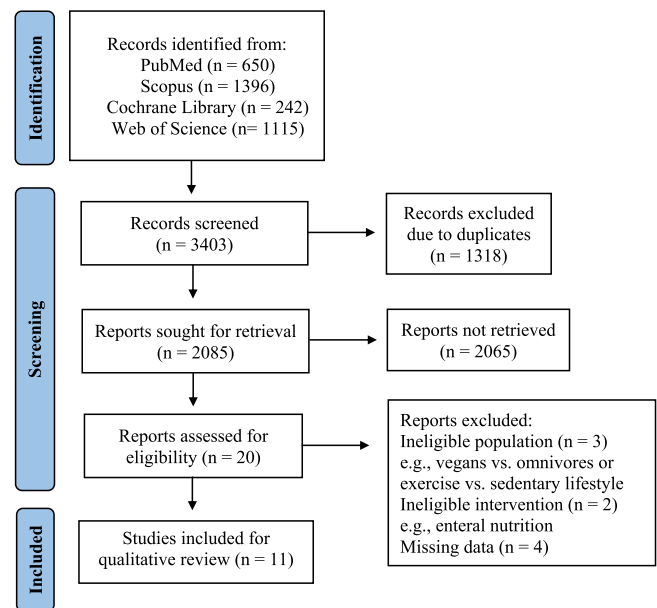


FIGURE 1 Flowchart of the employed literature search

and females. Two studies did not provide relevant information pertained to the total number of males and females.<sup>32,37</sup>

Further, four studies were RCTs,<sup>31,33,34,36</sup> two were double-blinded RCTs,<sup>37,40</sup> one was a crossover, open-label RCT,<sup>32</sup> one was an open label RCT<sup>39</sup> and three were clinical trials.<sup>30,35,38</sup> Moreover, seven used BCAA supplementation alone,<sup>30–34,37,38</sup> three co-supplemented vitamins and minerals<sup>35,36,40</sup> of which one followed a physical activity protocol,<sup>40</sup> and one followed a high-protein/high-fibre diet.<sup>39</sup> BCAA supplementation ranged from 4 weeks to 48 months in terms of duration and from 2.4 to 30 g day<sup>-1</sup> in terms of dosage.

Amongst the comparator groups, two studies used placebo controls,<sup>37,40</sup> of which one included physical activity,<sup>40</sup> one used an isocaloric control snack,<sup>36</sup> four used a usual diet regime,<sup>31–34</sup> one used a high-protein/high fibre diet<sup>39</sup> and three were single arm trials.<sup>30,35,38</sup>

Six studies included individuals with liver cirrhosis,<sup>30,34,36,37,39,40</sup> of which one experimented with sleep disturbance,<sup>34</sup> one with hepatocellular carcinoma (HCC),<sup>33</sup> two with hepatitis,<sup>32,38</sup> of which one included participants with insulin resistance,<sup>32</sup> one with portal vein embolisation (PVE) and sequential hepatectomy.<sup>31</sup>

### Serum insulin

BCAA supplementation led to conflicting results regarding serum insulin levels. Specifically, 8 g day<sup>-1</sup> of BCAA for 6 months, decreased serum insulin from 13.85 (6.6–18.6) U ml<sup>-1</sup> to 7.9 (5.0–96.9) U ml<sup>-1</sup> in patients undergoing PVE; however, similar changes were shown in the control group, which followed their usual diet

TABLE 1 Study and participant characteristics of the included studies

Reference (year)	Country	Study design	Total n (M/F)	BCAA		Comparator		Treatment dose (g day <sup>-1</sup> )	Treatment duration	Health status	Reported outcomes
				n (M/F)	Age (SD)	n (M/F)	Age (SD)				
Hernandez-Conde et al. <sup>40</sup>	Spain	Double-blind RCT	32 (28/4)	17 (15/2)	69 (9.7)	15 (13/2)	61 (9.4)	5.2	12 weeks	Cirrhosis	HOMA-IR
Ruiz-Margain et al. <sup>39</sup>	Mexico	Open-label RCT	72 (14/58)	37 (6/31)	54.9 (10.3)	35 (8/27)	47.8 (14.6)	8.6	6 months	Cirrhosis	Glucose
Kitajima et al. <sup>30</sup>	Japan	Clinical Trial	21 (9/12)	21 (9/12)	71.3 (7.9)	–	–	4	48 weeks	Cirrhosis	Insulin Glucose HOMA-IR
Ocana-Mondragon et al. <sup>38</sup>	Mexico	Clinical trial	20 (10/10)	20 (10/10)	53 (45.63)	–	–	30	3 months	Chronic hepatitis C	Insulin Glucose HOMA-IR
Beppu et al. <sup>31</sup>	Japan	RCT	28 (19/9)	13 (9/4)	64 (47–83)	15 (10/5)	72 (56–78)	8	6 months	PVE	Insulin Glucose HbA1c
Takeshita et al. <sup>32</sup>	Japan	Crossover, open label RCT	24	13	58.6 (2.9)	11	64.2 (3.0)	12.5	12 weeks	Hepatitis C IR	Insulin Glucose HOMA-IR HbA1c
Yoshiji et al. <sup>33</sup>	Japan	RCT	42 (26/16)	16 (10/6)	63.7 (10.8)	26 (16/10)	62.5 (11.5)	12	48 months	HCC	Glucose HOMA-IR
Ichikawa et al. <sup>34</sup>	Japan	RCT	21 (10/11)	12 (5/7)	66.2 (8.2)	9 (5/4)	67.4 (9.9)	13.5	8 weeks	Cirrhosis Sleep Disturbance	Glucose
Kawaguchi et al. <sup>35</sup>	Japan	Clinical Trial	12 (5/7)	12 (5/7)	64.3 (2.4)	–	–	6.4	90 days	Chronic liver disease	Insulin Glucose HOMA-IR HbA1c
Nakaya et al. <sup>36</sup>	Japan	RCT	38 (20/18)	19 (13/6)	67 (9)	19 (7/12)	67 (8)	12.3	3 months	Cirrhosis	Insulin Glucose
Marchesini et al. <sup>37</sup>	Italy	Double-blind RCT	61	29	60 (44–70)	32	60 (43–70)	2.4	3 months	Cirrhosis	Insulin Glucose

Abbreviations: BCAA, branched chain amino acid; F, female; HbA1c, glycated haemoglobin; HCC, hepatocellular carcinoma; HOMA-IR, homeostatic model assessment for insulin resistance; IR, insulin resistance; M, male; PVE, portal vein embolisation; RCT, randomised controlled trial.



(13.50 (4.4–18.8)–9.2 (2.7–38.8) U ml<sup>-1</sup>).<sup>31</sup> Furthermore, another study in patients with liver cirrhosis showed that 3 months of 2.4 g day<sup>-1</sup> BCAA slightly improved serum insulin (25 ± 17 to 23 ± 17 μU L<sup>-1</sup>) compared to placebo (casein) group (19 ± 10 to 22 ± 17 μU L<sup>-1</sup>), although no significant changes were observed.<sup>37</sup> By contrast, in patients with hepatitis C and insulin resistance, BCAA supplementation (12.5 g day<sup>-1</sup>) increased serum insulin levels after 12 weeks (13.8 ± 1.6 to 17.8 ± 3.6 μU L<sup>-1</sup>) as opposed to participants following their usual dietary patterns (23.3 ± 8.0 to 21.2 ± 4.6 μU L<sup>-1</sup>).<sup>32</sup> Furthermore, another study showed a substantial increase of serum insulin (16.2 ± 6.8 to 32.9 ± 34.5 μU ml<sup>-1</sup>) compared to an isocaloric control snack (21.3 ± 19.5 to 20.9 ± 14.4 μU ml<sup>-1</sup>) in patients with liver cirrhosis.<sup>36</sup> However, in this case the supplementary product consisted of BCAAs alongside vitamins and minerals. In the single arm studies, a high BCAA dose (30 g day<sup>-1</sup>) was slightly effective in reducing serum insulin levels (16 [11–31] to 14 [9–22] μU L<sup>-1</sup>) in patients with chronic hepatitis C when administered for 30 months,<sup>38</sup> whereas another study displayed a significant decrease of serum insulin (22.8 ± 9.7 to 13.3 ± 1.9 μU ml<sup>-1</sup>) after BCAA supplementation (6.4 g day<sup>-1</sup>) with vitamins and minerals after 90 days in patients with chronic liver disease.<sup>35</sup> Finally, one study demonstrated a small increase in serum insulin (14.2 ± 11.8 to 15.7 ± 16.5 μU ml<sup>-1</sup>) following a low BCAA dose (4 g day<sup>-1</sup>) in patients with liver cirrhosis for 48 weeks.<sup>30</sup>

## Serum glucose

Conflicting results were also observed on serum glucose after BCAA supplementation. In one study using 8.6 g day<sup>-1</sup> BCAA,<sup>39</sup> a small increase in serum glucose levels in the intervention (110.8 ± 52.9 to 112 ± 52 mg dl<sup>-1</sup>) group was observed as opposed to the control group (104.3 ± 45.4 to 94.1 ± 17.4 mg dl<sup>-1</sup>) in patients with liver cirrhosis when administered 6 months. Likewise, another study displayed a similar trend following 12.3 g day<sup>-1</sup> BCAA co-supplemented vitamins and minerals (107 ± 23 to 118 ± 39 mg dl<sup>-1</sup>) compared to an isocaloric snack group (99 ± 26 to 95 ± 10 mg dl<sup>-1</sup>).<sup>36</sup> Furthermore, another study also showed a small increase in the intervention (92.1 ± 2.1 to 96.6 ± 2.1 mg dl<sup>-1</sup>) compared to the usual diet group (100.6 ± 2.9 to 96.2 ± 2.0 mg dl<sup>-1</sup>).<sup>32</sup> On the other hand, a significant decrease in serum glucose levels (126.0 [75–184] to 98.0 (84–242) mg dl<sup>-1</sup>) was reported after 6 months with 8 g day<sup>-1</sup> BCAA supplementation compared to usual diet (101.0 [87–123 to 104.0 (90–125) mg dl<sup>-1</sup>) in patients with PVE.<sup>31</sup> No changes were seen in serum glucose levels of patients with HCC between the intervention (102.7 ± 30.6 to 95.4 ± 31.1 mg dl<sup>-1</sup>) and the control group (113.4 ± 28.8 to 107.8 ± 31.2 mg dl<sup>-1</sup>) following 12 g day<sup>-1</sup> for 48 months.<sup>33</sup> In addition, an identical trend was depicted in

patients with liver cirrhosis and sleep disturbance after 13.5 g day<sup>-1</sup> BCAA for 8 weeks (107.5 ± 27.2 to 105.7 ± 73.2 mg dl<sup>-1</sup>) against usual diet (115.4 ± 27.2 to 111.6 ± 24.2 mg dl<sup>-1</sup>).<sup>34</sup> In the single arm studies, serum glucose was reduced in each trial, however, no significant decrease was displayed (113.6 ± 31.7 to 108.5 ± 27.7 mg dl<sup>-1</sup>);<sup>30</sup> (124.2 ± 9 to 120.6 [109.9–133.3] mg dl<sup>-1</sup>);<sup>38</sup> (104.5 ± 6.4 to 102.8 ± 5.4 mg dl<sup>-1</sup>).<sup>35</sup>

## Glycated haemoglobin

No changes in HbA1c were observed following 12.45 g day<sup>-1</sup> BCAA supplementation for 12 weeks compared to usual diet in IR patients with hepatitis C (5.0% ± 0.1% to 4.9% ± 0.1% vs. 4.9% ± 0.1% to 5.0% ± 0.1%).<sup>32</sup> Additionally, no changes on HbA1c were revealed after consumption of 6.4 g/day BCAA for 90 days (5.5% ± 0.2% to 5.4% ± 0.3%).<sup>35</sup>

## Homeostatic model assessment for insulin resistance

The overall score of HOMA-IR was reduced following 5.2 g day<sup>-1</sup> BCAA co-supplemented with vitamins, minerals and physical activity after 12 weeks (4.9 ± 6.7 to 3.2 ± 1.8); however, no differences were observed compared to the physical activity and placebo group (6.3 ± 8.6 to 4.7 ± 3.2).<sup>40</sup> Similarly, identical findings were identified following 12 g day<sup>-1</sup> of BCAA supplementation for 12 weeks (3.55 ± 3.01 to 2.75 ± 2.08) against placebo (3.79 ± 2.92 to 3.61 ± 2.88).<sup>33</sup> Interestingly, an increase in HOMA-IR score was demonstrated after 12.45 g day<sup>-1</sup> for 12 weeks of BCAA (3.2 ± 0.4 to 4.5 ± 1.1) compared to usual diet that reduced HOMA-IR (6.1 ± 2.2 to 5.3 ± 1.3).<sup>32</sup> In the single arm studies, BCAA supplementation led to a decrease in HOMA-IR after 90 days as observed in (5.5 ± 2.1 to 3.5 ± 0.6)<sup>35</sup> and (3.5 (2.6–7.9) to 3.2 (1.9–5.0)).<sup>38</sup> Finally, a study revealed higher HOMA-IR scores following a 4 g day<sup>-1</sup> BCAA dose for 48 weeks (3.9 ± 3.0 to 4.5 ± 5.4).<sup>30</sup>

## Risk of bias

According to RoB2, risk of bias was high in one study<sup>31</sup> as a result of lack of information relevant to treatment allocation concealment and participants and trial personnel knowing about the type of intervention. Finally, some concerns were raised in three studies as a result of participants possibly knowing about the type of intervention.<sup>32,34,36</sup> A detailed traffic light plot is presented in Figure 2.

According to ROBINS-I, moderate risk of bias was displayed in one study as a result of insufficient control for confounders (i.e., physical activity).<sup>30</sup> Serious risk of

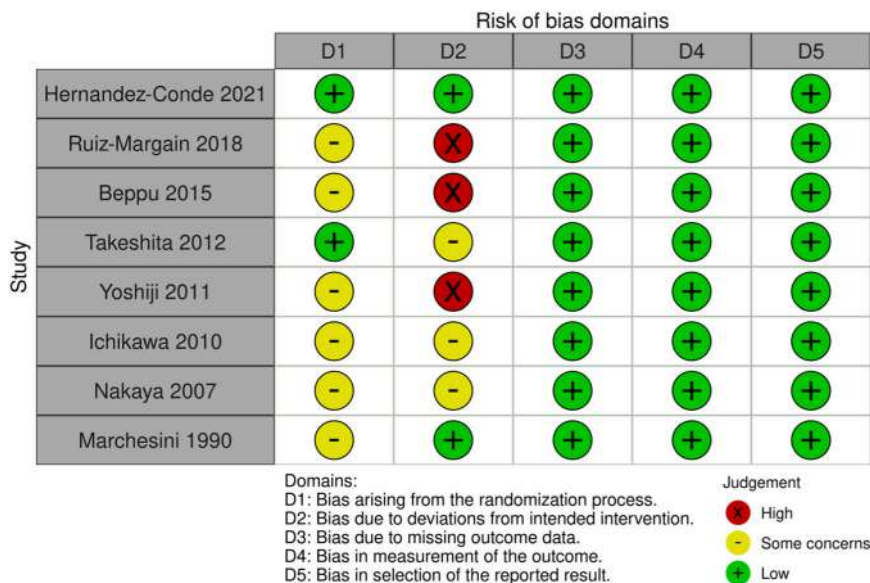


FIGURE 2 Quality assessment of the included studies according to the Cochrane Risk-of-Bias 2 (RoB2) tool for randomised trials

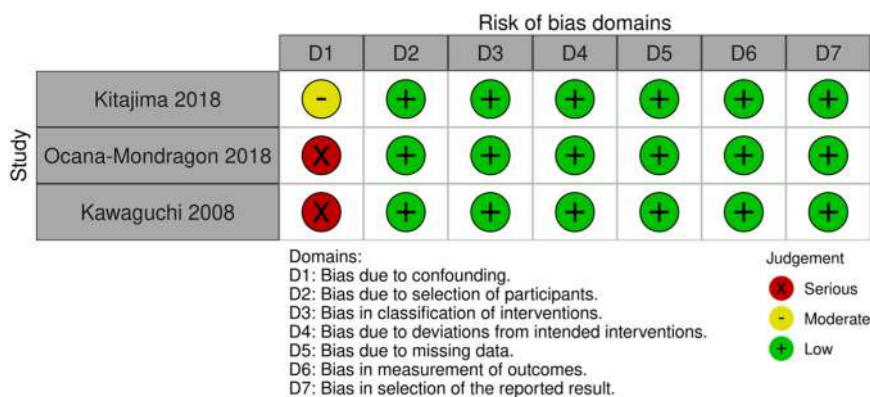


FIGURE 3 Quality assessment of the included non-randomised (single arm) studies according to the Risk Of Bias In Non-randomised Studies-of Interventions tool (ROBINS-I)

bias was observed in two studies as a result of no control for major confounding factors (i.e., diet and physical activity).<sup>38</sup> A detailed traffic light plot is presented in Figure 3.

## DISCUSSION

In this systematic review, we identified 11 studies examining the effects of BCAA supplementation on markers of glucose metabolism in participants with hepatic disorders. Overall, BCAA supplementation resulted in small decreases in serum insulin and HOMA-IR scores with no effect on serum glucose levels or changes in HbA1c.

The maintenance of physiological serum glucose is an essential component of glucose homeostasis, with impaired glycaemic control linked to a greater risk of chronic diseases such as type 2 diabetes (T2D) and cardiovascular disease.<sup>41,42</sup> A contributing factor to poor glycaemic control is IR. Epidemiological data has shown that IR and clinical diagnoses of T2D and prediabetes

are associated with elevated serum BCAAs.<sup>43</sup> By contrast to the observation of higher serum BCAA levels in those with IR or T2D, BCAA supplementation has been reported in some cases to improve measures of glucose homeostasis.<sup>44</sup> Recent research using Mendelian randomisation analysis has further clarified that elevated serum BCAAs are likely driven by the presence of IR and not the other way around (i.e., elevated serum BCAA do not drive IR).<sup>12</sup>

Animal models have revealed that a mechanism for the potentially beneficial effects of BCAA supplementation on glycaemic control is the activation of phosphoinositide-3 kinase (PI3K). This increase in insulin sensitivity and upregulation of glucose transporter protein 4 (GLUT4) may facilitate non-insulin mediated entry of glucose into cells.<sup>45</sup> Additional research in rat models has duplicated the observation of increased GLUT4 translocation to the skeletal muscle cell membrane as well as increased translocation of the GLUT1 glucose transporter protein.<sup>46</sup> The same research group observed an upregulation of glycogen synthase activity in leucine treated rats, which resulted in increased glycogen

content in soleus muscle compared to controls.<sup>46</sup> Such increased synthesis of glycogen by taking excess serum glucose out of circulation and storing it in skeletal muscle, could assist with overall glycaemic regulation.

Insulin sensitivity may be further affected by increased utilisation of glucose as fuel through glycolysis, via upregulation of GLUT2 and glucokinase in the liver, leading to improved bioactivity of the glucose-sensing apparatus.<sup>47</sup> Specifically, glucokinase is involved in the regulation of hepatic glycolysis and glucose oxidation, glycogen synthase, glycogenolysis and gluconeogenesis amongst others.<sup>48</sup> Therefore, BCAA supplementation may act as a partial substitute for insulin in glucose transport regulation by increasing glycogen synthesis in both skeletal muscle and liver. However, it should be noted that some research has reported conflicting results. Specifically, infusion of amino acids including leucine and isoleucine in human subjects has been reported to compete with glucose as an oxidative fuel, reducing glucose uptake.<sup>49</sup> Nevertheless, the aforementioned study involved venous infusion and not dietary supplementation of BCAAs, indicating that elevated serum levels of BCAAs may interfere with glycaemic control and not necessarily dietary intake.

Moreover, increased adiposity and in particular, skeletal muscle and liver tissue triglyceride (TG) accumulation are known to interfere with GLUT4 translocation and glucose uptake, mediated via the activation of insulin-stimulated PI3K, which may lead to IR.<sup>50</sup> In mouse models, supplementation with the BCAA isoleucine has been reported to reduce accumulation of TG in both skeletal muscle and liver tissue.<sup>51,52</sup> This is speculated to occur via upregulation of peroxisome proliferator-activated receptor- $\alpha$  and UCP2 in liver tissue and UCP3 in the skeletal muscle tissue. Thus, leading to increased free fatty acid oxidation, which results in improvements of insulin sensitivity induced by lipotoxicity.<sup>51,53</sup>

## Limitations

This systematic review is the first to examine the effects of isolated BCAA supplementation on markers of glucose metabolism in patients with hepatic disorders. The prevailing limitation of this review was the inability to produce a meta-analysis as a result of the heterogeneity in study designs. The large heterogeneity in protocols that can be observed in the populations included, the varied dosage of BCAA supplementation (2.4–30 g day<sup>-1</sup>), and study duration (4 weeks to 48 months). Furthermore, of the 11 studies included, seven involved Japanese populations, with the remaining four studies from the USA, Spain, Mexico and Italy, which may raise concerns regarding the generalisability of the results to other geographical regions or ethnicities. Finally, inconsistencies among dietary intakes among studies, in which

there was no control is a critical confounding factor in extrapolating more accurate conclusions regarding the effects of BCAA supplements in isolation.

## CONCLUSIONS

This systematic review revealed limited effects of isolated BCAA supplementation on overall glucose homeostasis among individuals with hepatic disorders, however, some improvements on serum insulin and HOMA-IR scores were observed. Studies should be aware of controlling strictly for dietary intake to omit the potential impact of other nutrients on glucose homeostasis and incorporate a placebo group as a comparator that would reduce bias risk. BCAA supplementation as an independent strategy appears to may not be an effective tool in improving glucose homeostasis in patients with hepatic disorders.

## AUTHOR CONTRIBUTIONS

*Study concept and design:* Konstantinos Prokopidis and Panagiotis Giannos. *Acquisition of data:* Konstantinos Prokopidis, Richard P. Kirwan and Konstantinos K. Triantafyllidis. *Analysis and interpretation of data:* Konstantinos Prokopidis, Richard P. Kirwan and Konstantinos S. Kechagias. *Drafting of the manuscript:* Konstantinos Prokopidis, Richard P. Kirwan and Panagiotis Giannos. *Critical revision of the manuscript for important intellectual content:* Konstantinos Prokopidis, Richard P. Kirwan, Panagiotis Giannos, Scott C. Forbes and Darren G. Candow.

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## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Effects of vitamin D supplementation on muscle function and recovery after exercise-induced muscle damage: A systematic review

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None

## Abstract

**Background:** Vitamin D is essential for the optimal health of the skeletal system. However, this vitamin is also involved in other functions of the human body, such as muscle, immune and inflammatory ones. Some studies suggest that adequate levels of vitamin D support muscular function during exercise and accelerate recovery because they reduce specific pro-inflammatory cytokine levels, but those results have not always been observed. Therefore, this review aims to evaluate the effects of vitamin D supplementation on inflammation, oxidative stress and recovery after exercise.

**Methods:** This systematic review was conducted using the Preferred Reporting of Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A literature search of SPORTDiscuss, PubMed, Web of Science and Scopus was performed from inception through February 2022. The articles' methodological quality was assessed with the PEDro scale.

**Results:** After the application of the inclusion and exclusion criteria, 11 eligible articles were included. All the studies were considered of moderate methodological quality. Ten studies involved regular vitamin D supplementation for more than 7 days, and one study performed acute vitamin D supplementation 24 h before exercise.

**Conclusions:** The existing evidence suggests that vitamin D supplementation for periods of more than 1 week with a minimum dose of 2000 IU/day appears to be an efficacious strategy for attenuating muscle damage and inflammation after exercise. The potential positive effects on muscle function, muscle pain and oxidative stress need to be confirmed with new investigations. Further research is also required to determine the adequate vitamin D dosage to obtain positive effects without adverse effects.

## KEYWORDS

inflammation, muscle damage, muscle soreness, oxidative stress, recovery, vitamin D

## Key points

- Regular vitamin D supplementation may be a good recovery strategy from strenuous exercise.
- Supplementation is effective with a minimum dose of 2000 IU/day for periods of more than 1 week.
- Athletes may also benefit from ingesting a single dose before exercise, but further research is needed.

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## INTRODUCTION

A free radical is an atom or a molecule with one or more unpaired electrons in its valency shell. This structure makes the atom or molecule unstable and highly reactive.<sup>1</sup> Free radicals are the products of cellular metabolism, and they are generated in the mitochondria when oxygen is used to produce ATP.<sup>2</sup> Among the most important free radicals generated in living cells are those derived from oxygen, referred to as reactive oxygen species (ROS).<sup>2,3</sup> At low or moderate levels, ROS exert beneficial effects in cells, serving as molecular signals, which activate stress responses beneficial to the organism.<sup>4</sup> However, at high concentrations, if they cannot be neutralised by the endogen antioxidant system, they generate a condition termed oxidative stress, which can cause severe damage to cell structures.<sup>2,5</sup>

Strenuous and prolonged muscular exercise, particularly after eccentric muscle actions, produces muscle damage and leads to an increase in ROS production that occurs primarily in skeletal muscles and generates oxidative stress, which negatively impacts exercise performance.<sup>6,7</sup> An optimum level of ROS is necessary for muscle fibres to generate 100% of their maximal isometric force production,<sup>8</sup> but any deviation from that optimal redox state decreases the muscles' ability to generate force.<sup>8,9</sup>

The human body has an endogen antioxidant system, which, together with the exogenous antioxidants consumed through the diet, is responsible for the elimination of ROS, maintaining the necessary redox balance.<sup>5</sup> Therefore, supplementation with antioxidant and anti-inflammatory substances may attenuate inflammation and oxidative stress, enhancing the recovery of muscle function after exercise,<sup>10</sup> which becomes particularly important for elite athletes.

Ibuprofen and non-steroidal anti-inflammatory drugs have been traditionally used to reduce inflammation and delayed onset muscle soreness,<sup>11</sup> but they have important gastrointestinal and cardiovascular adverse effects.<sup>6</sup> Therefore, there is an increasing interest in supplementation with natural antioxidant and anti-inflammatory foods, particularly polyphenol-rich foods, which have been associated with a range of health benefits.<sup>12</sup> Tart cherry, pomegranate or even green tea have been widely used in sports to accelerate muscle function recovery due to the antioxidant and anti-inflammatory properties of their phenolic compounds.<sup>13–15</sup>

Vitamin D is a fat-soluble vitamin that also appears to have anti-inflammatory and antioxidant properties.<sup>16</sup> It is considered a vitamin because small amounts of it are necessary for good human health. However, it is, in fact, a hormone because the required amount can be produced in the human body when the skin is exposed to ultraviolet solar radiation.<sup>17,18</sup> Its primary function is to regulate bone metabolism and calcium and phosphate absorption, which are necessary for bone mineralisation

and growth.<sup>19,20</sup> However, recent investigations have determined that this vitamin is also involved in other functions, such as muscular, inflammatory and immune ones, and may enhance sports performance.<sup>21–23</sup> At present, vitamin D supplementation is considered to be potentially protective from unfavourable COVID-19 outcomes.<sup>24</sup>

Although it is not known whether vitamin D has a direct impact on muscle function,<sup>25</sup> vitamin D receptors have been identified in muscle cells, which supports the idea of a direct impact on muscle contraction.<sup>26</sup> It has been suggested that vitamin D deficiency may affect the muscles' capacity for recovery after exercise.<sup>27</sup> Vitamin D has anti-inflammatory properties<sup>28</sup> because it down-regulates the synthesis of specific pro-inflammatory cytokines.<sup>29</sup> In fact, according to Choi et al.,<sup>30</sup> exercise-induced inflammation is significantly reduced in rats after vitamin D supplementation.

The two major physiologically relevant forms of vitamin D are vitamin D2 (ergocalciferol) and D3 (cholecalciferol).<sup>28</sup> The main source of vitamin D is endogenous production by the human body when it is exposed to sunlight.<sup>18</sup> Ultraviolet radiation converts 7-dehydrocholesterol present in the skin to vitamin D3.<sup>31,32</sup> In the liver, vitamin D3 is hydroxylated, generating 25(OH)D or calcidiol, and then it is further hydroxylated in the kidney to the active form 1,25(OH)2D or calcitriol.<sup>33</sup> Serum 25(OH)D has a half-life of 15 days, which makes it the best indicator of vitamin D levels in the human body.<sup>34</sup> Apart from endogenous production, the second source of vitamin D is the dietary intake, either as vitamins D2 or D3. Because it is fat soluble, its absorption improves when high-fat meals are consumed.<sup>35</sup>

The desirable levels of 25(OH)D required for good health are unknown. However, some authors recommend serum levels of 30–50 ng/ml. To that end, a daily intake of 600 international units (IU) for those aged less than 70 years and 800 IU for those 70 years or older is recommended.<sup>36,37</sup> However, other authors suggest that those quantities are not sufficient to obtain benefits in athletic performance.<sup>16,38</sup> With regard to human toxicity, according to Holick,<sup>18</sup> toxicity has not been associated with daily intakes of 10,000 IU for periods of up to 5 months. More recently, Adebayo et al.<sup>39</sup> concluded in their review that none of the 3353 subjects included in the randomised controlled trials analysed reported any adverse effect with vitamin D doses of 200–7000 IU.

In humans, it has been reported that vitamin D contributes to optimal muscle function, even in physically inactive older people.<sup>40</sup> According to some authors,<sup>41,42</sup> adequate levels of vitamin D support muscle contraction during exercise and enhance muscle recovery due to the downregulation of specific pro-inflammatory cytokines. Moreover, some studies suggest that vitamin D supplementation reduces exercise-induced muscle damage (EIMD).<sup>30</sup> Nonetheless, not all research studies

carrying out a vitamin D supplementation have observed significant reductions in inflammatory markers after exercise.<sup>43,44</sup>

Due to the contradictory results observed of the effects of vitamin D supplementation on muscle function and recovery after exercise and because we have not found any review on this subject, this systematic review aims to summarise the effects of vitamin D supplementation on muscle damage and recovery after EIMD in humans.

## METHODS

The protocol for this systematic review was designed in accordance with the Preferred Reporting of Systematic Reviews and Meta-Analyses (PRISMA) statement<sup>45</sup> and registered at PROSPERO (CRD42022321140). The two authors independently performed the literature search, the study selection and the data extraction. Any disagreement was resolved by consensus.

### Inclusion and exclusion criteria

The studies included in this systematic review fulfilled the following inclusion criteria: (i) research conducted with human participants, (ii) original articles in peer-reviewed publications, (iii) original studies that had investigated only vitamin D supplementation on muscle damage and recovery after exercise, (iv) research conducted with one control/placebo group and (v) articles published from inception to February 2022. Exclusion criteria were: (i) research conducted with animals, (ii) non-English articles, (iii) systematic reviews or meta-analyses, (iv) studies that underwent other interventions in addition to vitamin D supplementation and (v) studies that reported results inadequately or without adequate statistical analysis.

### Search strategy and data extraction

Four electronic databases were searched: SPORTDiscus, PubMed, Web of Science and Scopus. The search was limited to publications in English and journal articles. The following search was performed: (vitamin D OR ergocalciferol OR cholecalciferol) (Title) AND (supplement\*) (Title) AND (muscle damage OR oxidative stress OR recovery OR exercise OR muscle pain OR antioxidant OR inflammation OR soreness [Title]) AND (sports OR exercise OR physical activity OR training [all fields]). A manual search of the reference sections of selected articles was also made to identify additional relevant studies. The search strategy is depicted in Figure 1.

After applying inclusion and exclusion criteria the following data were extracted from each study: first

author name, year of publication, the intervention and placebo group characteristics, dosage of supplements, supplementation duration, exercise protocol to induce muscle damage and the effects of supplementation on functional measures, muscle soreness and markers of muscle damage, inflammation and oxidative stress.

### Methodological quality assessment

The methodological quality of the articles was assessed with the PEDro scale, which is based on the Delphi list developed by Verhagen et al.<sup>46</sup> and is a reliable and objective tool that helps identify which studies are likely to be externally valid (criterion 1), internally valid (criteria 2–9) and could have sufficient statistical information to make their results interpretable (criteria 10 and 11).<sup>13</sup> Points are awarded only when a criterion is clearly satisfied, and criterion one, which relates to external validity, is not used to calculate the PEDro score. A score of 9–10 on the PEDro scale was considered to be ‘high quality’, scores of 5–8 were deemed to be ‘moderate quality’ and scores below 5 were considered to be ‘low quality’.<sup>6</sup>

## RESULTS

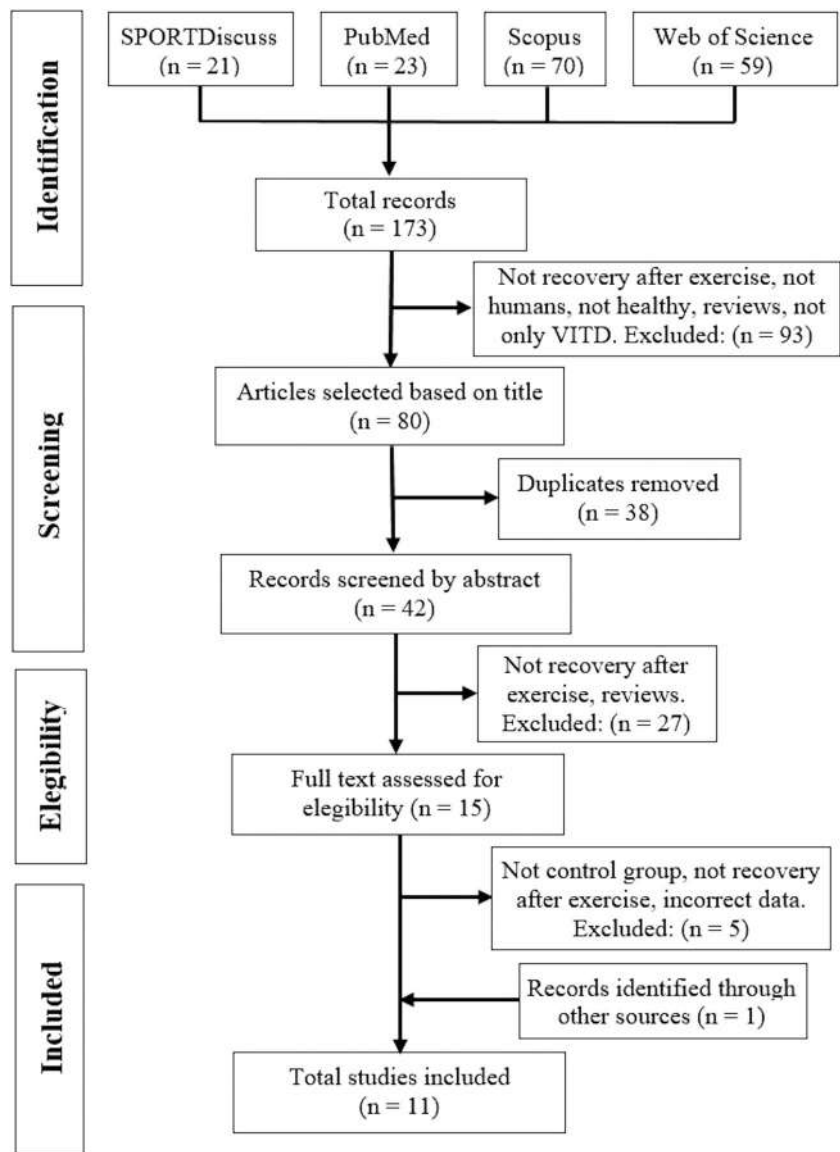
### Search results

The literature search provided a total of 173 articles identified through the combined descriptors. After examination of the titles, 93 articles were excluded for not studying recovery after exercise, not being conducted with humans, carrying out a supplementation other than sole vitamin D or because they were systematic reviews. After the elimination of duplicates, 42 articles were selected for abstract screening and 27 of them were also excluded for not studying recovery after exercise or for being systematic reviews. Fifteen studies were then selected for full-text reading, and five of these were excluded for not studying recovery after exercise, not having a control group or reporting results inadequately. One study was added from the reference lists of selected articles, and the final number of studies in this systematic review was 11.<sup>43,44,47–55</sup> A summary of the search process is depicted in Figure 1.

### Study characteristics

The characteristics of the included studies are summarised in Table 1. All studies were randomised controlled trials with a parallel design. One of them<sup>48</sup> had two experimental groups, with different baseline levels of vitamin D, and two control groups, and the results from all of them were included. Three

FIGURE 1 Flowchart for identification and selection of eligible studies for the systematic review



studies<sup>49,51,53</sup> used more than two experimental arms, but only the vitamin D and control group results were reported in the review.

The sample size was 10–22 participants in each group. Only three studies<sup>51,52,54</sup> performed an a priori statistical power analysis and used adequate sample sizes based on those estimations. All the selected studies were conducted with healthy or apparently healthy subjects, except one<sup>51</sup> whose participants were considered healthy but suffered from non-specific perceived myalgia. Seven studies were conducted with men,<sup>43,47,48,50,52,53,55</sup> three with women<sup>47,51,54</sup> and one with men and women.<sup>44</sup> The mean age of the participants ranged from  $15.90 \pm 0.29$  years to  $42.40 \pm 7.59$  years. Five studies evaluated the effects of vitamin D supplementation on sedentary to moderately active people,<sup>47–49,53,55</sup> five studies on highly active people<sup>43,44,50,52,54</sup> and one did not mention the participants' fitness level.<sup>51</sup>

All but one study<sup>52</sup> evaluated the effects of regular vitamin D ingestion for a minimum period of 7 days, with a vitamin D dose per day of 600–7000 IU. Mieszkowski et al.<sup>52</sup> supplemented with a single dose of 150,000 IU 24 h before exercise. The precise vitamin D content of the dosages and the duration of the supplementation period are presented in Table 1. Seven studies used a special protocol to induce muscle damage,<sup>43,47–50,52,55</sup> which differed substantially across them (Table 1). Four studies measured functional measures, markers of muscle damage, inflammation and oxidative stress before and after a period of normal training.<sup>44,51,53,54</sup>

### Functional measures and muscle soreness

Three studies<sup>43,47,51</sup> analysed the effects of vitamin D supplementation on any of the following functional

TABLE 1 Characteristics of the included studies

Study	Participants	Groups	Age (years)	Vitamin D content	Supplementation period	Exercise protocol to induce muscle damage
Barker et al. (2013)	Healthy and modestly active men	15 (VITD) 13 (CON)	30 ± 6 31 ± 5	4000 IU/day	35 days (exercise on Day 28)	10 sets of 10 repetitive jumps at 75% of body mass with 20 s rest between sets
Shanely et al. (2014)	Male healthy students participating in varsity sports	17 (VITD) 16 (CON)	16.6 ± 0.23 15.9 ± 0.29	600 IU/day	42 days (exercise on Day 42)	Modified Lough-borough Intermittent Shuttle Test + leg lunges
Todd et al. (2017)	Healthy male and female young Gaelic footballers	22 (VITD) 20 (CON)	20 ± 2 20 ± 2	3000 IU/day	12 weeks	Normal training
Pilch et al. (2020)	Healthy young men with low or moderate physical activity	18 (VITD1) 18 (CON1) 18 (VITD2) 18 (CON2)	20–24	Specific for each athlete (more than 2000 IU/day)	3 months (exercise at the end)	Incremental exercise test to voluntary exhaustion on a treadmill
Vakili et al. (2020)	Healthy young untrained female students	15 (VITD) 15 (CON)	24.73 ± 1.57 24.53 ± 1.59	3800 IU/day	7 días (exercise on Day 7)	Five sets of four repetitions of quadriceps leg extension at 120% de 1RM with both legs
Żebrowska et al. (2020)	Male ultramarathon Caucasian runners	12 (VITD) 12 (CON)	33.7 ± 7.5 35.9 ± 5.3	2000 IU/day	21 days (exercise at the end)	30-min downhill running test at 70% of the individual VO <sub>2</sub> peak
Abdeen et al. (2021)	Relatively healthy obese women	15 (VITD) 15 (CON)	34.8 ± 2.64 35.4 ± 2.69	50,000 IU/week (~7000 IU/day)	12 weeks	Normal training
Mieszkowski et al. (2021)	Healthy male semi-professional ultramarathon runners	16 (VITD) 19 (CON)	42.40 ± 7.59 39.48 ± 6.89	150,000 IU	One single dose (24 h before exercise)	Ultramarathon
Nikniaz et al. (2021)	Healthy sedentary male smokers	10 (VITD) 10 (CON)	30.40 ± 4.08 31.30 ± 4.00	6000 IU/week (1000/day except Fridays)	28 days	Normal training
Stojanović et al. (2021)	Healthy female professional or semi-professional young basketball players	12 (VITD) 12 (CON)	19.4 ± 4.0 19.8 ± 4.6	4000 IU/day	42 days	Normal training
Mastali et al. (2022)	Healthy non-athlete men	13 (VITD) 13 (CON)	24.33 ± 2.7 25.83 ± 3.18	2000 IU/day	42 days (exercise at the end)	Exhaustive Bruce aerobic test

Abbreviations: COD, cross-over design; CON, control group; IU, international units; RM, repetition maximum; VITD, vitamin D group.

variables: maximal isometric voluntary contraction (MIVC) of the lower limb, single-leg peak power output, maximal power during a vertical jump, leg-back 'deadlift' strength and Cooper 12-min walk test. Only Barker et al.<sup>47</sup> observed a better recovery of MIVC of the lower limb in the experimental group (EG). Four studies<sup>43,47,49,51</sup> evaluated muscle soreness after exercise, and two of them<sup>49,51</sup> found significantly lower values in the EG at some point after exercise or throughout the entire recovery period (Table 2).

## Muscle damage

Seven studies<sup>43,47–50,54,55</sup> analysed serum or plasma concentration of any of the following markers of muscle damage: aspartate aminotransferase (AST), alanine aminotransferase (ALT), myoglobin (MB), lactate dehydrogenase (LDH), creatine kinase (CK) and alkaline phosphatase (ALP). All but Shanely et al.<sup>43</sup> observed significant differences between groups in any of the markers measured after exercise or at some point of the recovery period (Table 2).

TABLE 2 Variables measured and summary of findings of the included studies

Study	Functional measures and muscle soreness	Biochemical markers of muscle damage, inflammation and oxidative stress	Significant differences in VITD group (vs. CON group).
Barker et al. (2013)	Muscle soreness of the lower limb, MIVC and peak power of the lower limb Measurements: baseline, pre, post, 1, 24, 48, 72 and 168 h post	Plasma: AST, ALT Measurements: baseline, pre, post and 1, 24, 48, 72 and 168 h post	>Recovery of MIVC 24 h post <AST 168 h post <ALT 48 and 72 h post
Shanely et al. (2014)	Muscle soreness, vertical jump power and leg-back 'dead.lift' strength Measurements: baseline, pre, post, 24 and 48 h post	Serum: MB, LDH, CK, AST Measurements: baseline, pre, post, 24 and 48 h post	No significant differences between groups
Todd et al. (2017)	-	Plasma: TNF- $\alpha$ , IL-8, CRP, LL-37 Measurements: pre and post (after an overnight fast)	No significant differences between groups
Pilch et al. (2020)	-	Serum: MB; plasma: CK y LDH Serum: IL-1 $\beta$ Measurements: pre, 1 h post and 24 h post	<CK pre and 1 h post (Group 2) <LDH pre and 1 h post (Group 1) <IL-1 $\beta$ pre and 1 h post (Group 1)
Vakili et al. (2020)	Muscle soreness Measurements: baseline, pre, 24, 48 and 72 h post	Serum: CK Serum: IL-6 Serum: MDA Measurements: baseline, pre, 24, 48 and 72 h post	<Muscle soreness 24 and 48 h post <CK 48 h post <IL-6 24 and 48 h post <MDA 48 h and 72 h post (comparisons between groups not reported but great differences observed)
Żebrowska et al. (2020)	-	Serum: MB, CK, LDH Serum: IL-6; TNF- $\alpha$ Measurements: baseline, pre, post, 1 h and 24 h post	<CK 24 h post <IL-6 24 h post
Abdeen et al. (2021)	Cooper 12-min walk test, muscle soreness Measurements: baseline and post (after an overnight fast)	-	<Muscle soreness post
Mieszkowski et al. (2021)	-	Serum: FSTL-1, IL-6, IL-10, IL-15, resistin, LIF, OSM, TIMP-1 Measurements: 24 h pre, post and 24 h post	< IL-6; IL-10 and resistin post
Nikniaz et al. (2021)	-	Serum: IL-6, TNF- $\alpha$ Measurements: baseline and 24 h post (after an overnight fast)	<TNF- $\alpha$ post <IL-6 post (tendency)
Stojanović et al. (2021)	-	Serum: LDH, CK. Measurements: baseline and 36 h post (after an overnight fast)	<LDH variation post <CK variation post
Mastali et al. (2022)	-	Serum: CK, LDH, ALT, AST, ALP Serum: GGT Measurements: pre and post	<LDH and CK post <ALT, AST, GGT and ALP pre and post

Abbreviations: ALP, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate transaminase; CK, creatine kinase; CRP, C-reactive protein; FSTL-1, follistatin-like 1; GGT, gamma-glutamyl transferase; IL, interleukin; LDH, lactate dehydrogenase; LIF, leukaemia inhibitory factor; LL-37, antimicrobial peptide LL-37; MB, myoglobin; MDA, malondyaldehyde; MIVC, maximal isometric voluntary contraction; OSM, oncostatin M; TIMP-1, tissue inhibitor of metalloproteinase 1; TNF- $\alpha$ , tumour necrosis factor alpha.

## Inflammation and oxidative stress

Six studies<sup>44,48–50,52,53</sup> measured any of the following inflammatory markers: tumour necrosis factor alpha (TNF- $\alpha$ ); interleukin (IL) 1 $\beta$ , 6, 8, 10 and 15; C-reactive protein (CRP); antimicrobial peptide LL-37 (LL-37);

follistatin-like 1 (FSTL-1); leukaemia inhibitory factor (LIF); oncostatin M (OSM); tissue inhibitor of metalloproteinase 1 (TIMP-1). All of these studies, except Todd et al.,<sup>44</sup> found significantly lower levels of inflammation in EG after exercise or at some point in the recovery period.



One study<sup>53</sup> measured serum levels of malondialdehyde (MDA), and another one<sup>55</sup> determined serum levels of gamma-glutamyl transferase (GGT). Both observed lower levels in EG at any point after exercise. A complete summary of the findings for markers of inflammation and oxidative stress can be seen in Table 2.

### Methodological quality assessment

All studies were considered to be of moderate quality. Quality scores ranged from 6 to 8 (of a maximum of 10) and had a mean PEDro score of  $7.63 \pm 0.67$ . No study was excluded due to its low quality. Table 3 details the results of the criteria evaluated. All studies failed to blind all assessors who measured at least one key outcome (item 7), and only one three<sup>51,53,55</sup> carried out a concealed allocation (item 3).

## DISCUSSION

Supplementation with antioxidant and anti-inflammatory substances is currently used to a substantial degree in sport to attenuate EIMD and accelerate recovery after exercise.<sup>14,56</sup> Vitamin D has demonstrated marked anti-inflammatory properties, and recent studies have investigated whether vitamin D supplementation attenuates muscle damage and enhances recovery after exercise. However, the results are inconclusive.

To the best of our knowledge, this is the first systematic review to examine the effectiveness of vitamin D supplementation on recovery after EIMD in humans. Eleven studies met our inclusion criteria, involving a total of 364 participants. Our review suggests that vitamin D supplementation may attenuate the extent of muscle damage and inflammation, subsequently enhancing recovery after exercise.

### Functional measures and muscle soreness

Of the three studies that evaluated muscle function,<sup>43,47,51</sup> only Barker et al.<sup>47</sup> observed a better recovery of the MVIC of the lower limb in the EG 24 h after exercise. Abdeen et al.<sup>51</sup> also noticed an increase in the distance covered during the Cooper test, but this increase was not significant. Of the four studies that measured muscle soreness, Shanely and co-workers<sup>43,47</sup> did not find significantly lower muscle soreness values in EG, that vitamin D supplementation attenuated muscle soreness, although Barker et al.<sup>47</sup> observed a tendency. However, the other two articles<sup>49,51</sup> obtained lower levels of muscle soreness in the EG, suggesting that vitamin D supplementation does, in fact, reduce muscle soreness.

Only Shanely et al.<sup>43</sup> did not observe a better recovery of muscle function or a reduction in muscle

soreness and not even a tendency. They used a dosage of 600 IU/day, a particularly low amount of vitamin D compared to the other studies, potentially explaining why they did not achieve the expected results. Moreover, the authors did not even find differences between groups in serum vitamin D levels after a supplementation period of 7 weeks.

It appears that vitamin D supplementation with 4000 IU/day or more for more than 7 days could, therefore, accelerate the recovery of functional measures and attenuate muscle soreness after EIMD. However, due to the few studies included and because not all of them obtained positive results, new studies are required to confirm the effectiveness of vitamin D supplementation.

### Muscle damage

Six of the seven studies that analysed muscle damage obtained significantly lower values in the EG in any of the markers measured after exercise or at some point during the recovery period. Only Shanely et al.<sup>43</sup> did not observe significant differences between groups. Again, the low daily dosages of vitamin D may be the cause of these unexpected results. Recently, Iolascon et al.<sup>57</sup> investigated the effects of vitamin D on muscle tissue through genomic and non-genomic pathways, concluding that vitamin D supplementation enhances the structural and functional restoration of the muscles, by increasing the expression of myogenic factors in satellite cells during recovery from muscle damage.

In this regard, our review indicates that supplementation with dosages of 2000 IU/day or more for a total period of more than 7 days is an effective strategy for reducing EIMD. Supplementations with other functional foods, such as tart cherry or pomegranate,<sup>13,14</sup> have obtained contradictory results, with some studies reporting beneficial effects and others not. Thus, we can conclude that vitamin D supplementation seems to be more effective for attenuating EIMD.

### Inflammation

Six of the seven studies that analysed inflammatory markers<sup>44,48–50,52,53</sup> found significantly lower values in the EG. The reason why Todd et al.<sup>44</sup> did not observe those results may have been that they did not study inflammation after a particular protocol to induce muscle damage, but after normal training sessions. Those normal sessions might not have generated sufficient muscle damage and, therefore, vitamin D supplementation conferred no benefits for inflammation. In addition, biochemical analyses were not performed after the training but the next morning, after an overnight fast, and the biomarkers would have already reached their normal ranges in both groups. In fact, the



TABLE 3 Methodological quality of the included studies assessed with the PEDro scale

Items	Barker et al. (2013)	Shanely et al. (2014)	Todd et al. (2017)	Pilch et al. (2020)	Vakili et al. (2020)	Żebrowska et al. (2020)	Abdeen et al. (2021)	Mieszkowski et al. (2021)	Nikniaz et al. (2021)	Stojano-vić et al. (2021)	Mastali et al. (2022)
1. Eligibility criteria were specified	+	+	+	+	+	+	+	+	+	+	+
2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	+	+	+	+	+	+	+	+	+	+	+
3. Allocation was concealed	-	-	-	-	-	-	+	-	+	-	+
4. The groups were similar at baseline regarding the most important prognostic indicators	+	+	+	+	+	+	+	+	+	-	+
5. There was blinding of all subjects	+	+	+	+	+	+	+	+	-	+	+
6. There was blinding of all therapists who administered the therapy	+	+	+	-	+	+	-	+	-	+	-
7. There was blinding of all assessors who measured at least one key outcome	-	-	-	-	-	-	-	-	-	-	-
8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	+	+	-	-	+	+	+	+	+	+	+
9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome were analysed by 'intention to treat'	+	+	+	+	+	+	+	+	+	+	+
10. The results of between-group statistical comparisons are reported for at least one key outcome	+	+	+	+	+	+	+	+	+	+	+
11. The study provides both point measures and measures of variability for at least one key outcome	+	+	+	+	+	+	+	+	+	+	+
Total score	8	8	8	6	8	8	8	8	7	7	8

concentrations of most of the cytokines that the authors wished to analyse were undetectable or fell below the lower limit of detection and were finally excluded from the statistical analyses.<sup>44</sup>

There is some controversy regarding whether vitamin D reduces inflammation or, on the contrary, it is inflammation that reduces vitamin D levels.<sup>28,58</sup> However, there is some evidence that has associated various inflammatory diseases and vitamin D deficiency and that has outlined the potential role of vitamin D supplementation for reducing the risk of developing those diseases.<sup>28</sup> Regarding the exercise-induced inflammation, our results suggest that vitamin D supplementation for more than a week with dosages of more than 2000 IU/day lowers the inflammatory response triggered after EIMD.

After analysing the results of other systematic reviews on supplementations with tart cherry, pomegranate or beetroots,<sup>14,15</sup> with some studies not reporting beneficial effects on inflammation levels, we can conclude that vitamin D supplementation seems to be more effective for reducing inflammation after exercise than other functional foods.

## Oxidative stress

The positive effects on lowering oxidative stress markers observed by Vakili and co-workers<sup>49,55</sup> indicate that vitamin D might exhibit antioxidant properties. However, these findings may have been due to reduced inflammation because, after muscle damage is generated, the inflammatory response further increases ROS production.<sup>59</sup> Therefore, if vitamin D reduces inflammation, it could also have reduced oxidative stress indirectly.

According to Mokhtari et al.,<sup>60</sup> it seems that vitamin D plays an important role in the prevention of some chronic diseases, such as diabetes, because it regulates oxidative stress. However, the authors conclude that there are few 'in vivo' studies that have examined that hypothesis. More recently, Tagliaferri et al.,<sup>61</sup> in their review of randomised controlled trials conducted with humans, concluded that the role of vitamin D as an antioxidant cannot be confirmed because contradictory results have been provided in the literature to date. Our findings suggest that vitamin D reduces oxidative stress after exercise, but there were only two studies included. Therefore, new scientific evidence is required to confirm the antioxidant effect of vitamin D supplementation.

## Limitations

This review has several limitations: (i) Not all the studies used a specific protocol to induce muscle damage and when they did, the exercise protocol varied substantially between them, inducing different levels of muscle damage. Moreover, the varying training statuses of the

participants affected the magnitude of the muscle damage experienced. (ii) Only three studies performed an a priori statistical power analysis; therefore, the sample sizes may not have been sufficiently large to detect small changes in the markers analysed. (iii) There were substantial differences in the dosages of vitamin D and in the supplementation periods.

## CONCLUSIONS

Despite the limitations mentioned, the studies included in this systematic review suggest that vitamin D supplementation, with at least 2000 IU/day, during periods of 1 week or more, reduces muscular damage and inflammation after exercise. Studies regarding the effects on muscular function and muscle soreness are scarce, and they show contradictory results; further research is warranted. Only two studies investigated the effects of vitamin D supplementation on oxidative stress and despite the positive results observed, further analyses are also necessary. These new investigations should focus on determining the optimal vitamin D dosage to obtain positive effects and the possible adverse effects of supplementation for periods of more than 3 months.

## AUTHOR CONTRIBUTIONS

The study was designed by the two authors. Conceptualisation, investigation, methodology, study selection, data extraction, data interpretation, writing, editing and preparation of the manuscript were also undertaken by the two authors. Both authors reviewed and approved the final version of the article.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## TRANSPARENCY STATEMENT


The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. The reporting of this work is compliant with PRISMA guidelines.

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# To feed or let eat! A scale of independence, exploration, and family to measure baby-led weaning as a complementary feeding approach

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## Abstract

**Background:** This article reports the development and validation of a measure of parents' use of baby-led weaning (BLW). BLW is a child-centred approach to complementary feeding where the infant is allowed to eat whole foods (rather than purees) and explore a variety of foods and textures. To date, parents' use of BLW has been assessed using either single items or a wide variety of measures. **Method:** In this study, exploratory and confirmatory factor analyses on independent samples supported three BLW subscales: independence, exploration, and family.

**Results:** The final 13-item scale showed adequate fit statistics and good reliability ( $\chi^2(62) = 115.02, p < 0.001$ ; CFI = 0.98; TLI = 0.98; RMSEA = 0.05; SRMR = 0.06; exploration  $\alpha = 0.738$ ; family  $\alpha = 0.715$ ; independence  $\alpha = 0.809$ ). In addition, the scale demonstrated good external validity and related in theoretically expected ways to an infant feeding-style measure and parent report of complementary feeding approach. This study was limited as it was mostly white parents, and the scale should be validated on a more diverse sample.

**Conclusions:** Future research can use this scale to examine if BLW relates to infant taste preferences, parenting styles, and child eating behaviours to improve child nutrition and health outcomes.

## KEYWORDS

baby-led weaning, complementary feeding, infant feeding style

## Key Points

- To date, there is limited operationalisation of BLW as a complementary feeding style.
- This study created a scale to measure BLW as a complementary feeding style.
- Three main factors emerged from the items: exploration, independence, and family.
- Future research should target the effects of BLW on child nutrition and feeding outcomes.

## INTRODUCTION

Parents typically begin complementary feeding, or the introduction of foods other than breast milk or formula, during their infants' first year of life.<sup>1</sup> Within the past

100 years, it has been traditional in Western cultures for parents to spoon-feed the child purees or baby food.<sup>2</sup> With this method, the parent leads the feeding interactions by controlling the spoon. In the early 2000s, an alternative approach to complementary feeding known

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as baby-led weaning (BLW) was introduced and became popular globally.<sup>3</sup> BLW encompasses a philosophy that the child is the leader in the feeding relationship. Behaviourally, it generally involves the parent following the infants' cues as they feed themselves from the same or similar foods that the family is eating.<sup>4,5</sup> Although BLW has increased in popularity and potentially plays an important role in the early development of eating behaviours, only limited empirical research has investigated the construct, and this research has been conducted outside of the United States. Furthermore, operationalisation and measurement of BLW as a complementary feeding style are not well established.

Early literature on BLW considered this construct qualitatively, examining themes related to parents' experience with BLW and the challenges that come with it. In three studies of paediatricians in Spain, a majority of health professionals indicated that they have some familiarity with BLW, but only half of them recommended it for parents to use.<sup>6-8</sup> Similarly, research indicates that healthcare professionals in New Zealand and Brazil are reluctant to recommend BLW because of the increased risk of choking for infants and potential problems with iron and overall energy intake.<sup>9,10</sup> However, some Brazilian professionals recognised that there may be some advantages to adopting BLW.<sup>10</sup> Parents reported learning about BLW online or from a family member or friend.<sup>4</sup> Others transitioned to BLW when attempts at traditional spoon-feeding failed.<sup>11</sup> Across qualitative studies, parents reported that they enjoy this feeding approach as it allows the child to learn to accept different foods and textures in an environment with little pressure.<sup>12</sup> They can trust their child in the exploration of food.<sup>9</sup> In turn, children are able to learn to trust their satiety cues and respond to their body when hungry, and parents hope that these skills will continue into their childhood.<sup>4,11</sup> In addition, parents reported that BLW encourages independence with food and eating.<sup>10</sup> In particular, D'Andrea et al. found that parents using BLW report less mealtime stress and more convenience as they can share meals with their child and the child can use food to develop their fine motor skills.<sup>4</sup>

However, not all reported experiences with BLW were positive. Many parents indicated anxiety about their child gagging and choking as part of learning how to feed themselves.<sup>4,11,12</sup> Moreover, parents noted that it was difficult to allow the baby to lead their experience with food, and many parents worried about inadequate nutrient intake.<sup>13</sup> Finally, parents noted that they had received inconsistent advice and information on BLW. In particular, high-quality information was challenging to locate, and some of the information given was not consistent with current recommendations by national health organisations.<sup>12,14</sup> Many mothers noted that they felt confused by the information that they had access to and had to lean on personal experience when they chose how to introduce solid foods to their baby.<sup>11</sup>

Research has also considered BLW using quantitative methodologies. In general, these studies have found that BLW is characterised by the child being able to explore foods with different tastes and textures while still being nutritionally supported by breast milk or infant formula.<sup>5</sup> In addition, this approach to feeding is distinguished by sharing meals with the family, which includes eating the same foods served to other family members.<sup>3</sup> In particular, a study conducted by D'Andrea et al. examined the types of foods that were given first and the way they were presented to the child.<sup>4</sup> They found that parents engaging in BLW started by offering various fruits and vegetables. Then parents moved to offering their children animal-based proteins.<sup>4</sup> These foods are kept whole or solid as opposed to being pureed or in liquid form and are typically given in soft strips that the child can grasp.<sup>4,13</sup>

Correlates and outcomes of BLW, such as children's dietary intake and satiety responsiveness, have also been investigated. There are mixed findings on infants' energy intake when parents adopt BLW. One study found that infants whose parents use BLW consume more fat and less iron and vitamin B<sub>12</sub> than those who use a traditional complementary feeding approach.<sup>15</sup> Contradicting this finding, Rowan et al. and Williams Erickson et al. found that there were no differences in dietary intake between older infants whose parents adopted BLW or spoon-feeding.<sup>16,17</sup> Erickson found that children whose parents adopted a BLW approach were more likely to consume meat, dairy products, and powdered infant cereal. However, there were no differences in consumption of fruits, vegetables, bread, pasta, rice, and low sugar cereals.<sup>18</sup> Research that examines differences in satiety responsiveness in infants between the different feeding styles also had mixed findings. For example, Brown and Lee found that children who were given solid foods in BLW were more responsive to their satiety.<sup>19</sup> In contrast, other literature found no differences in responsiveness to satiety based on the feeding approach.<sup>3,20</sup> Finally, one study evaluated parental personality differences as predictors of the complementary feeding they utilised and found that parents who scored lower on anxiety and restrained eating and higher on extraversion and conscientiousness were more likely to adopt a BLW approach to introduce solids to their infant.<sup>21</sup>

Most of the previous literature has measured BLW using a single dichotomous (yes/no) item or a series of questions that vary widely among studies. However, it is likely that even parents who use BLW incorporate it into their feeding to differing degrees; thus, this dichotomous approach likely does not capture the variability among parents. In addition, researchers have noted a lack of operational definition for BLW as an infant feeding approach.<sup>18,19,22-24</sup> One extant scale examines parents' perceptions of BLW and whether it is a safe method to start complementary feeding.<sup>25</sup> However, to date, no scale is available to measure the degree to which parents



adhere to the ethos of BLW or to capture the multidimensionality of BLW. Therefore, this study aimed to operationalise and create a scale to measure BLW.

## ITEM GENERATION AND SCALE CONSTRUCTION

In part 1, we developed items to measure BLW, examined the underlying factor structure in an exploratory factor analysis (EFA), and tested the relationship of the subscale scores to a single-item assessment of BLW. This study was approved by the Institutional Review Board of the authors' university.

## MATERIALS AND METHODS

### Survey participants

A total of 393 individuals were recruited for the first study via Cloud Research, an online platform that allows people to complete surveys for compensation.<sup>26</sup> Interested participants selected this study to complete and were then directed to a Qualtrics survey. The consent form was the first page of the survey, and participants could not continue the survey without consenting. The consent form listed the eligibility criteria. If they did not consent or did not meet eligibility criteria, they were directed to the last page of the survey that indicated they had nothing more to complete. The survey could be completed in less than 20 min, and participants were compensated 50 cents. Participants had to be a parent who lived in the United States with a child between age 6 and 30 months. The total number of children in the family was not specified, but parents were allowed to complete the survey as long as they had one child within the required age range. In addition, parents who used any form of complementary feeding (i.e., spoon-feeding, BLW, or a combination of the two) could participate; 224 participants were excluded as they signed up for the study but were not able to go further than the consent form due to not meeting eligibility criteria. An additional 20 individuals were excluded from the analyses due to not meeting data quality requirements. These 20 individuals completed the study but did not pass two of the three required attention checks throughout the survey. The final sample included 149 parents; 67.8% of participants identified as female, having a middle-class income (55.7%), and a bachelor's degree (40.3%). In addition, 79.9% identified their race/ethnicity as white/Caucasian, followed by African American or black (8.1%), Asian (7.4%), Latinx (4.7%), and Native American (2.7%). According to Osborne and Costello, for an initial EFA, a ratio of five participants to each scale item is adequate.<sup>27</sup>

### Item generation

Researchers completed a review of literature related to BLW, complementary feeding, and finger foods and introducing solids using Google Scholar, PubMed, PsychInfo, and Academic Search Complete. Furthermore, the authors surveyed news articles and blogs to investigate what parents think BLW is and how this method of complementary feeding functions in the home. From these search methods, the main themes that were generated by parents and health professionals were adapted into survey items to reflect the philosophy, practice, and foods served in BLW. In addition, the pressure and control items were generated from previous scales, including responsive feeding measures. From this literature, 31 items were generated. These items included the philosophy of BLW (e.g., my infant should be allowed to explore the foods presented to them), practices of BLW (e.g., my baby brings the food up to their mouth), the use of pressure and control in BLW (e.g., I restrict the amount of food my child is allowed to eat during a meal; reverse coded), and foods served in BLW (e.g., I feed my child from baby food jars; reverse coded). Face validity was examined by the authors to ensure the scale items captured the underlying construct. In particular, researchers ensured that the items were congruent with the results of the previous literature conducted in other countries and with other scales that measure similar constructs. Participants rated each item on a five-point Likert scale ranging from strongly disagree or never to strongly agree or all of the time. These 31 items were pretested with a small sample ( $n = 5$ ) of individuals who met eligibility criteria, and feedback on the items was collected. These individuals completed the survey via Qualtrics and were asked to give feedback via email, text message, or by phone to the researchers. Two items that were noted as ambiguous were revised before recruiting the larger sample. The item 'What is your race/ethnicity' was adapted to say 'What category best describes your race/ethnicity? Select all that apply'. In addition, the item 'I feed my infant cereal' was modified to say 'I feed my infant cereal (e.g., rice cereal, oatmeal)'.

In addition, a single item to examine the external validity of the scale was included in the survey after asking about the parent's current beliefs surrounding complementary feeding. This item read 'The feeding approach known as "baby led weaning" or "BLW" for short is a style of feeding infants that allows them to feed themselves right from the start of introducing solid foods. One aspect of this is that food is offered in thick finger-sized pieces and is soft and easily squishable between your fingers. Another approach is called spoon-feeding, where most of the foods introduced are in the form of purees and are eaten off of a spoon. When introducing new foods to your child, which style of feeding did you use?' Parents responded on a five-point

Likert scale of BLW, mostly BLW with some spoon-feeding, an equal amount of spoon-feeding and BLW, mostly spoon-feeding with some BLW, and spoon-feeding. A higher score on this item indicates following BLW.

Finally, an infant feeding measure was included to examine the external validity of this scale using infant feeding style. This 51-item scale included subscales of laissez-faire (e.g., it is okay for a toddler to walk around when eating as long as he or she is eating), pressuring (e.g., it is important for a toddler to finish all food on his or her plate), restrictive (e.g., a toddler should never eat sugary food like cookies), and responsive (e.g., my child knows when he or she is full). This scale has adequate reliability and validity.<sup>28</sup>

### Item analysis and scale construction

Thirty-one items, with no missing data, were analysed using EFA using principal component analysis with an oblimin rotation. The EFA was performed in SPSS Statistics software version 27.<sup>29</sup> The point of inflection on the scree plot, eigenvalues >1, the contribution of meaningful variance, loadings and cross-loadings, and theoretical interpretability were used to select the number of factors and eliminate poorly performing items.

## RESULTS

Initial analyses showed that there was adequate variance on all 31 items. Thirteen items were excluded iteratively based on the criteria outlined earlier. In particular, eight items were eliminated as they did not contribute meaningful variance to the scale, and five items were excluded as they were the only item on a factor. Then, one item was removed due to its cross-loading across all the factors (i.e., my infant should be given the same foods as the family is eating [possibly in addition to breast milk]). Finally, two items were excluded as they negatively affected the Cronbach's  $\alpha$  reliability test between the subscales (i.e., my infant uses utensils when they eat, I offer foods to my child when they are content and happy). Then, a final EFA on 15 items was conducted. The Kaiser–Meyer–Olkin statistic was 0.82, and Bartlett's test of sphericity was  $\chi^2(91) = 748.62$ ,  $p < 0.001$ , suggesting that the sample size was adequate for the analysis. All three components of the final EFA had an eigenvalue above 1 and combined explained 56.53% of the total variance. These three components were labelled (1) exploration, (2) independence, and (3) family. The  $\alpha$  values for the scales were 0.79, 0.83, and 0.74, respectively.

Subscale scores (item means) were calculated and correlated with one another to examine if the subscales

were related with each other in theoretically expected ways. All subscales were significantly positively correlated (Table 1). Each subscale was also significantly positively correlated with the single-item complementary feeding approach reported by the parent (independence:  $r = 0.28$ ,  $p < 0.001$ ; exploration:  $r = 0.30$ ,  $p < 0.001$ ; family  $r = 0.27$ ,  $p < 0.001$ ). In addition, sex differences were calculated between each subscale. In the sample in part 1, there was a significant difference from the exploration subscale ( $t(147) = -2.52$ ,  $p = 0.013$ ) such that mothers ( $M = 3.45$ ) reported allowing significantly more exploration in their approach to complementary feeding than fathers ( $M = 3.15$ ). There were no significant differences for the independence (mothers:  $M = 3.32$ ; fathers:  $M = 3.15$ ) ( $t(147) = -1.82$ ,  $p = 0.071$ ) or family (mothers:  $M = 2.86$ ; fathers:  $M = 2.77$ ) ( $t(147) = -0.616$ ,  $p = 0.539$ ) subscales. In the sample that was recruited in part 2, there were significant differences between the subscales that measured exploration ( $t(162) = -3.80$ ,  $p < 0.001$ ) and independence ( $t(162) = -5.07$ ,  $p < 0.001$ ) such that mothers (exploration:  $M = 3.64$ ; independence:  $M = 3.04$ ) reported more independence and exploration tendencies in their complementary feeding approach than fathers (exploration:  $M = 3.20$ ; independence:  $M = 2.58$ ). The family subscale did not show sex differences (mothers:  $M = 3.20$ ; fathers:  $M = 3.04$ ) ( $t(162) = -1.78$ ,  $p = 0.078$ ).

Finally, the BLW subscales were correlated with the infant feeding–style subscales (Table 1). All three subscales (i.e., independence, exploration, and family) were significantly negatively related to the pressure and restriction subscales of the infant feeding style. In addition, the independence and exploration subscales of the BLW scale were significantly positively related to the responsive subscale of the infant feeding styles.

## SCALE REFINEMENT AND FINAL VALIDATION

To ensure that the factor structure would be maintained in an independent sample, in part 2, we tested a confirmatory factor analysis (CFA) in a separate sample of parents.

## MATERIALS AND METHODS

### Survey participants

For this study, 339 parents were recruited via cloud research. The same recruitment methods and informed consent process were utilised as in part 1. Cloud research ensured that participants who participated in part 1 could not participate in part 2; 131 potential participants were excluded as they did not meet

TABLE 1 Original scale items

1. My infant should be given the same foods as the family is eating (possibly in addition to formula/breast milk).
2. My infant should be allowed to explore the foods presented to them.
3. How much do you believe the statement 'Food is fun until age one'.
4. My infant should eat different foods than what the family eats. <sup>a</sup>
5. My infant should have special mealtimes that are planned just for them. <sup>a</sup>
6. My infant should sit with the family at mealtime.
7. My infant uses utensils when they eat. <sup>a</sup>
8. My infant is allowed to feed themselves.
9. My infant holds food pouches when presented to eat.
10. I feed my child so they do not have to touch the food. <sup>a</sup>
11. I play games (e.g., airplane and choo-choo train) to get my child to eat more. <sup>a</sup>
12. Meals are messy with my infant.
13. My baby brings the food up to their mouth.
14. I feed my child. <sup>a</sup>
15. My baby feeds themselves.
16. I introduce new foods frequently.
17. I allow my child to explore new foods.
18. I offer foods when my baby has already had some breast milk.
19. I offer foods to my child when they are content and happy.
20. I offer foods to my child when they are fussy. <sup>a</sup>
21. I offer foods to my child when they are hungry. <sup>a</sup>
22. I restrict the amount of food my child is allowed to eat during a meal. <sup>a</sup>
23. I decide when my child stops eating. <sup>a</sup>
24. I pressure my child into eating more. <sup>a</sup>
25. When my child is done eating, I ask/tell my child to eat more. <sup>a</sup>
26. I offer small portions of various foods to my child for a meal.
27. I feed purees to my baby. <sup>a</sup>
28. I feed my child from baby food jars. <sup>a</sup>
29. I give my child strips of soft foods to eat.
30. My infant eats the same foods as I provide for my family (in addition to breast milk/formula).
31. I feed my infant cereal (e.g., rice cereal, oatmeal).

<sup>a</sup>Indicates the item is reverse coded. This scale is rated on a five-point Likert scale that ranges from strongly disagree to strongly agree.

eligibility criteria (i.e., a parent with a child between age 6 and 30 months). An additional 33 participants were excluded from analyses as they did not successfully complete the data quality requirements for this study for a final sample of 175 parents. A majority of participants were female (70.7%), white/Caucasian (73.8%), had a socio-economic status in the middle class (50.6%), and had completed a bachelor's degree (34.8%).

## RESULTS

Data from the second survey were used to confirm the factor structure of the scale through CFA in r studio.<sup>30</sup> The fit of the model using 15 items was adequate ( $\chi^2(87) = 197.44$ ,  $p < 0.001$ ; comparative fit index [CFI] = 0.96; Tucker-Lewis index [TLI] = 0.96; root mean square error of approximation [RMSEA] = 0.07; standardized root mean squared residual [SRMR] = 0.08).

TABLE 2 Correlations between BLW subscales and infant feeding style questionnaire in sample 1

	1	2	3	4	5	6
1. Independence						
2. Exploration	0.557**					
3. Family	0.582**	0.410**				
4. IFS-laissez-faire	-0.081	-0.135	0.032			
5. IFS-pressure	-0.368**	-0.309**	-0.326**	0.229**		
6. IFS-restriction	-0.335**	-0.279**	-0.386**	-0.248**	0.571**	
7. IFS-responsiveness	0.196*	0.325**	-0.006	0.109	0.000	0.207*

Abbreviations: BLW, baby-led weaning; IFS, infant feeding-style questionnaire.

\*\* $p < 0.01$  (two-tailed); \* $p < 0.05$ .

TABLE 3 Correlations between BLW subscales in sample 2

	1	2	3	<i>M</i>	<i>SD</i>
1. Independence				2.90	0.617
2. Exploration	0.511**			3.51	0.642
3. Family	0.363**	0.398**		3.15	0.504

Abbreviations: BLW, baby-led weaning; *SD*, standard deviation.

\*\* $p < 0.01$  (two-tailed).

Two of the items had low factor loadings on the independence latent variable. These items were less face valid for the subscale (i.e., I feed purees to my baby, I give my child strips of soft foods to eat) and did not contribute meaningful variance and so were excluded from the scale. After these items were excluded, the CFA analysis was rerun with 13 items. With the 13-item scale, the fit of the model was improved, and overall a good fit was observed ( $\chi^2(62) = 115.02$ ,  $p < 0.001$ ; CFI = 0.98; TLI = 0.98; RMSEA = 0.05; SRMR = 0.06).

Subscale scores (item means) were calculated and correlated with one other to examine if the subscales were related with each other in theoretically expected ways. Similar to part 1, the subscales significantly positively correlated with each other (Table 2). Again, all three subscales of the BLW scale significantly positively were related to the single item that asked parents which approach of complementary feeding they followed, indicating that parents who reported using BLW also scored higher on the BLW measure (exploration:  $r = 0.25$ ,  $p < 0.001$ ; independence:  $r = 0.34$ ,  $p < 0.001$ ; family:  $r = 0.30$ ,  $p < 0.001$ ). The Cronbach's  $\alpha$  values were 0.738, 0.715, and 0.809 for the exploration, family, and independence subscales, respectively (Tables 3 and 4).

## DISCUSSION

The aim of the current research was to create a scale to measure BLW. To date, no operational definition of BLW or no scale that measures BLW as an approach to

start complementary feeding exists. This initial creation and examination of the validity of the BLW scale yielded positive results. Part 1 provided a new scale to operationalise and measure BLW. In the EFA, a three-factor solution was obtained. The subscales showed good internal consistency in the sample of parents whose children had started eating solid foods or had recently gone through the process of complementary feeding. The results of this initial scale development suggest that BLW can be measured by three components: first, the degree to which the child has independence in eating; second, how much the child is allowed to explore their food (e.g., textures, colours, and tastes); and third, the extent to which the infant sits with and eats with the family. Interestingly, items that asked about pressure and restriction were excluded from analyses as they did not load consistently with the other items and factors on the scale. This suggests that pressure and restriction are separate constructs that are not related to practices associated with BLW. These results are consistent with previous literature and articles that describe BLW as an approach when starting complementary feeding<sup>7,11,13</sup> and are consistent with how parents think about BLW in qualitative studies.<sup>4</sup>

This new measure of BLW allows the parent's approach to complementary feeding to be examined along a continuum. Indeed, in the sample in part 1, a majority of parents (68.3%) use a combination of complementary feeding approaches (i.e., item was rated on a five-point Likert scale that included (1) spoon-feeding, (2) mostly spoon-feeding and some BLW, (3) equal amount of both spoon-feeding and BLW, (4) mostly BLW and some spoon-feeding, and (5) BLW). That is, most parents do not adhere to one complementary feeding philosophy and, therefore, should not be forced to choose between BLW and spoon-feeding in classifying themselves, as they have typically done in previous research. Another advantage of this new scale is that parents who have not heard the term 'baby-led weaning', but who follow this approach anyway, still score high on the measure, giving a more accurate view

TABLE 4 Final scale items

	Factor 1	Factor 2	Factor 3
1. My infant should have special mealtimes that are planned just for them. <sup>a</sup>	1.000		
2. My infant should eat different foods than what the family eats. <sup>a</sup>	0.874		
3. My infant eats the same foods as I provide for my family (in addition to breast milk or infant formula).	1.109		
4. My infant should sit with the family at mealtime.	0.690		
5. My infant should be allowed to explore the foods presented to them.		1.000	
6. I introduce new foods to my child frequently.		1.117	
7. I allow my child to explore new foods.		1.546	
8. My infant is allowed to feed themselves.			1.000
9. My infant holds food pouches when presented to eat.			0.674
10. I feed my child so they do not have to touch the food. <sup>a</sup>			0.515
11. My baby brings the food up to their mouth.			0.913
12. My baby feeds themselves.			0.955
13. I feed my child from baby food jars. <sup>a</sup>			0.539

Abbreviation: BLW, baby-led weaning.

<sup>a</sup>Indicates the item is reverse coded. Factor 1 was labelled family, factor 2 was labelled exploration, and factor 3 was labelled independence. This scale is rated on a five-point Likert scale that ranges from strongly disagree to strongly agree.

of their feeding approach. Finally, in the samples recruited in parts 1 and 2 of this study, both mothers and fathers were recruited. Most previous literature that has focused on BLW has included only mothers in the sample.<sup>4,6,9,11,13,17–19</sup> Including fathers in the validation of the scale indicates that they are involved in food decisions with their children. Considering this, future research can create a more complete picture of parental beliefs of child complementary feeding styles.

The factor structure of the measure revealed that parents who use BLW may hold different values about feeding than those who use traditional spoon-feeding. Whereas BLW prioritises independence, exploration, and the baby eating with the family, traditional spoon-feeding approaches prioritise parent-led feeding with purees and the infant not being included in family meals. Indeed, Brown and Lee<sup>31</sup> found that parents who follow a BLW approach self-report using lower levels of controlling and restrictive feeding practices. It is also likely that BLW relates to demographic variables such as socio-economic status, race, ethnicity, and education status. For example, parents with higher education and of particular ethnicities may be more exposed to BLW and in turn more likely to adopt this way of complementary feeding. Indeed, Langley-Evans discussed in their editorial how BLW is more popular in the United Kingdom among high-income families.<sup>32</sup> In addition, as BLW is child centred and allows the child to explore at their own pace, it is important to consider how parenting style is related. Parents who have different levels of responsiveness and place different demands on their children may be more likely to adopt a particular infant

feeding style. Finally, it is important to understand how BLW relates to family dynamics. Given that maladaptive family dynamics can have negative effects on children (e.g., lower psychological well-being, self-esteem, and more behavioural problems<sup>33,34</sup>), examining how BLW fits into familial patterns of interaction might be worthwhile. Furthermore, examining how BLW might be implemented in non-traditionally structured families, such as single-parent families, would be useful in future research.

Perhaps most proximally, it is important to understand how BLW may relate to children's eating behaviours, and it is hoped that a standard measure for this construct will help in this endeavour. Disordered eating behaviours can manifest early in life,<sup>35</sup> and early disordered eating patterns are a risk factor for developing an eating disorder as a teenager or an adult.<sup>36</sup> Because the development of intuitive eating patterns can be a protective factor against disordered eating,<sup>37</sup> it is important to investigate how BLW relates to responsive feeding, children's eating behaviours, and hunger and satiety responsiveness.

## LIMITATIONS

Although this scale development represents an important step forward in research on BLW, it has its limitations. This sample was recruited via Cloud Research/Amazon's Mechanical Turk. Therefore, the parents who completed the study may have more experience with and access to technology. In addition, participants on mTurk are more



likely to not have other employment, be more educated, and be less religious.<sup>38</sup> All these characteristics may be associated with greater exposure to ideas about various complementary feeding approaches. In addition, the samples in these studies lacked racial and ethnic diversity. Thus, additional research is needed to understand this construct with more diverse samples. In addition to these issues of sampling, these studies relied on parents' self-report. Observational research to corroborate these results would be very useful. Furthermore, parents with children aged 6 months to 2½ years were recruited for this study as they were in the process of complementary feeding or recently went through the experience and could retrospectively report about the experience. However, this may have impacted the scale development if parents were not able to accurately retrospectively report about their feeding. Therefore, this study should be replicated to confirm the factor structure of this scale.

Moreover, previous research examining BLW was conducted outside of the United States, and there may be cultural differences in feeding practices and the principles of BLW cross-culturally. For example, in the United States, parents commonly give food pouches to children to hold and eat on their own. This might be a practice that is congruent with BLW because the child is in control and leading the eating occasion. In the United Kingdom, however, this practice is discouraged due to oral health and other concerns. Therefore, future research should investigate the possible differences in BLW practices across difference cultures to gain a more complete scenario of how BLW manifests in different countries.

Finally, exploration, independence, and family emerged as the three basic tenets of a BLW approach to complementary feeding based on this study and previous literature. However, it is possible that there is more to BLW than these themes. For example, some researchers have identified other tenets of BLW such as continuing breastfeeding/formula feeding on demand or introducing solid foods around 6 months. Therefore, future research should continue to investigate how parents view BLW and what are the most salient aspects of this approach in relation to positive and negative eating outcomes.

## CONCLUSION

This initial BLW scale creation and validation yielded positive results. After EFA and CFA analyses, the final scale included 13 items that form three subscales. Future research might use this continuous approach to measuring BLW to examine taste preferences, weight status, and feeding patterns in children whose parents use this approach. Furthermore, as more information on the consequences of BLW versus parent-led feeding becomes known, future research should investigate perceptions

and opinions of BLW from health providers, because paediatricians may be a key source of information for parents on complementary feeding. Given the challenges associated with childhood nutrition, understanding early factors that may help protect against poor nutrition and weight outcomes may have important public health consequences.

## AUTHOR CONTRIBUTIONS

Emma Studer-Perez contributed to theory, item generation, data collection, analyses, and manuscript preparation. Dara Musher-Eizenman contributed to theory, analyses, and writing and editing of the manuscript and overall support of the project.

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In addition, there were no external sources of funding for these studies. No other individual contributed to the creation of this work.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. The reporting of this work is compliant with CONSORT guidelines. The lead author affirms that no important aspects of the study have been omitted. All materials and analysis codes can be obtained by emailing the corresponding author. This study, hypotheses, and analytic plan were preregistered with Open Science Framework. The registration is available at [https://osf.io/5zjne/?view\\_only=8a3f0971a63a442dac2ec7a299457bbf](https://osf.io/5zjne/?view_only=8a3f0971a63a442dac2ec7a299457bbf). Finally, this manuscript was part of the transparent peer review process. All correspondence between the authors and reviewers is available upon request.

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# Association between receipt of nutritional counselling during antenatal care visits and anaemia: A cross-sectional study

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## Abstract

**Background:** Anaemia during pregnancy is associated with premature births, low birth weight and increased susceptibility to infection. Almost one-quarter (24.34%) of Ethiopian pregnant women suffer from anaemia. Nutritional counselling during antenatal care (ANC) visits may encourage pregnant women to take a more iron-rich diet and prevent anaemia. The present study examines the association between nutritional counselling during ANC and anaemia among Ethiopian women.

**Methods:** This cross-sectional study uses the 2016 Ethiopia Demographic and Health Survey (EDHS) data ( $n = 4,384$ ). The outcome of interest was anaemia, measured objectively by blood haemoglobin level. The main independent variable was the receipt of nutritional counselling during ANC visits. Univariate, bivariate and multivariable analyses were performed using SAS, version 9.4 (SAS Institute Inc.).

**Results:** Overall, 25.8% of the participants were anaemic and 65.7% received nutritional counselling during ANC visits. Compared with women who received nutritional counselling during ANC visits, a significantly higher proportion of women who did not receive nutritional counselling were anaemic (23.1% vs. 30.8%;  $p < 0.001$ ). In the multivariable model, compared with women who received nutritional counselling during their ANC visits, the odds of being anaemic were higher among women who did not receive nutritional counselling during their ANC visits adjusted odds ratio = 1.34 (95% confidence interval = 1.07–1.67;  $p = 0.010$ ).

**Conclusions:** In a representative sample of Ethiopian women, exposure to nutritional counselling during ANC visits is associated with a lower likelihood of anaemia, independent of potential confounders. Focused ANC counselling that includes nutritional counselling programs during ANC visits can be an effective strategy to prevent and control anaemia.

## KEYWORDS

anaemia, antenatal care visit, demographic and Health Survey, Ethiopia, nutritional counselling

## Key points

- Exposure to nutritional counselling during antenatal care visits is associated with a lower likelihood of anaemia, independent of potential confounders.
- Nutritional counselling during antenatal care visit can be an effective strategy to prevent and control anaemia.

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## INTRODUCTION

Anaemia refers to a clinical condition in which the amount of healthy red blood cells or blood haemoglobin (Hb) concentration is lower than normal.<sup>1</sup> The normal level of Hb, an iron-containing protein found in the red blood cells, varies from person to person depending on age, gender or physiological conditions.<sup>2–4</sup> A decrease in Hb concentration leads to a lower oxygen-carrying capacity of red blood cells, which hinders the proper functioning of human body system as a result of insufficient oxygen supply.

Iron deficiency anaemia is considered the most common type of anaemia worldwide, especially in developing countries. Iron is an essential part of Hb, with iron deficiency anaemia occurring when iron intake or absorption does not meet human body's iron requirement. Increased physiological iron demand during growth and pregnancy puts young children and pregnant women at higher risk for iron deficiency anaemia.<sup>5</sup> The global anaemia prevalence in 2019 was estimated to be 22.8%,<sup>6</sup> whereas anaemia prevalence in women of reproductive age was 29.9% and 39.8% in children aged 6–59 months.<sup>7</sup> Thus, anaemia is a major public health problem that affects children and women disproportionately.<sup>8</sup> Africa and South Asia are the two areas where anaemia is most common.<sup>9</sup> The Ethiopian National Nutritional Program called for reducing anaemia among pregnant women from 22% to 12% in 2015. However, according to the 2016 Ethiopian Demographic and Health Survey (EDHS), 29% of pregnant women were anaemic.<sup>10</sup>

Anaemia is a leading cause of maternal mortality in developing countries. Anaemia during pregnancy can adversely affect the wellbeing of both the mother and the fetus. Maternal anaemia is associated with significant health problems such as haemorrhage and postpartum infection.<sup>11</sup> It can also cause miscarriage,<sup>12</sup> premature births<sup>13</sup> or low birth weight.<sup>14,15</sup> Furthermore, prenatal iron deficiency can lead to delays in the neurocognitive development of infants.<sup>16</sup>

Iron deficiency anaemia can be treated with iron supplementation or by increasing daily dietary intake of iron-rich foods.<sup>17–19</sup> The World Health Organization recommends daily oral iron supplementation for pregnant women to prevent maternal anaemia.<sup>20</sup> Routine screening of asymptomatic pregnant women for iron deficiency anaemia can limit the prevalence of maternal anaemia. Public health interventions that focus on educating pregnant women about screening for anaemia, healthy eating, and important sources of vitamins and minerals are essential to reduce the burden of iron deficiency anaemia in developing countries. Nutritional counselling of mothers during antenatal care (ANC) encounters can be used to promote sustainable food-based strategies, such as dietary diversification, that have

been known to effectively combat micronutrient deficiencies in developing countries.<sup>21–23</sup> In areas where supplemental sources are available, nutritional counselling of mothers during ANC can be used to promote continued and consistent use of food supplements, including fortified foods, and improve awareness and adherence to iron supplementation.<sup>24</sup>

Several studies have shown that providing nutritional education and counselling during pregnancy can reduce the risk of anaemia.<sup>25–29</sup> Pregnancy is a teachable moment and motivating time for women to engage in health behaviour modification.<sup>30</sup> Exposure to nutritional counselling during antenatal ANC encounters may have a lasting impact on the nutritional status of women. Such an encounter may empower and motivate women to adopt a healthy lifestyle after giving birth. Studies examining the effect of nutritional education and counselling during pregnancy on the risk of anaemia have primarily focused on maternal and infant health outcomes during pregnancy or in the early postpartum period.<sup>25–28,31</sup> However, studies examining the long-term impact of exposure to nutritional counselling during ANC on anaemia status after giving birth, especially in low- and middle-income countries, are currently lacking. The present study aimed to assess the effect of receiving nutritional counselling during ANC visits on current anaemia status in a large, nationally representative sample of Ethiopian women.

## METHODS

The present study is based on the 2016 EDHS, a cross-sectional population-based survey conducted every five years. The 2016 EDHS is the fourth and the most recent Demographic and Health Survey (DHS) in Ethiopia. Participants were selected using a stratified two-stage cluster sampling technique using the 2007 Ethiopian population and Housing Census as the sampling frame. Eligible participants for women's interviews included women aged 15–49 years. In the 2016 EDHS, 15,683 women were interviewed. The current study is restricted to women who had a live birth in the 5 years preceding the survey with at least one ANC visit during their most recent birth ( $n = 4712$ ). Participants with missing data on anaemia status ( $n = 231$ ) and those who do not know the number of ANC visits ( $n = 18$ ) were excluded. Additionally, participants with missing data on covariates included in the multivariable model ( $n = 79$ ) were excluded. The final study sample consisted of 4384 women. Data were downloaded after the DHS program granted permission to access the data. The current study was deemed exempt from a full review by the institutional review board of the author's institution because it was based on de-identified secondary data.



## Outcome of interest: anaemia

Blood samples were collected from women aged 15–49 years who consented to be tested for anaemia. Blood samples were drawn from a drop of blood taken from a finger prick and collected in a microcuvette. A portable battery-operated HemoCue 201+ (HemoCue) was used for haemoglobin (Hb) testing.<sup>32</sup> This technique has been widely used for rapid results, and the results are comparable to standard laboratory techniques. Test results were provided verbally and in writing. Non-pregnant women in whom the Hb level was below 7 g dl<sup>-1</sup> and pregnant women in whom the Hb level was below 9 g dl<sup>-1</sup> were instructed to visit a health facility for follow-up care. Additionally, all educational materials that explain the causes and prevention of anaemia were provided. The definition of anaemia in the present study is consistent with the DHS program's definition of anaemia, a Hb level of <11 g dl<sup>-1</sup> for non-pregnant women and <12 g dl<sup>-1</sup> for pregnant women. Haemoglobin levels were adjusted for cigarette smoking and the altitude in areas 1000 m above sea level.

## Exposure variable: receipt of nutritional counselling during ANC visit

In the 2016 EDHS, women who received ANC for their most recent birth in the past 5 years were asked if they were provided with nutritional counselling services during their ANC visit. Responses to this item were coded as 1 (yes) or 0 (no).

## Covariates

Based on existing literature, sociodemographic and other characteristics including age, marital status, parity, pregnancy status, education, employment, household health index, residence, body mass index, number of ANC visits, type of delivery, hormonal contraception use, deworming medication use, iron tablets use and HIV status were assessed.

## Statistical analysis

Frequency and proportion were used to describe the characteristics of the study sample. A Rao-Scott chi-squared test was used to examine differences in the proportions of anaemia by receipt of nutritional counselling and each covariate examined in the current study. Multivariable-adjusted odds ratios (OR) and corresponding 95% confidence intervals (CIs) were reported. All variables were retained in the multivariable logistic regression regardless of statistical significance in the bivariate analysis. The consistency of the association

between receipt of nutritional counselling and anaemia were examined by performing a stratified analysis by age, education, and household wealth index. Multicollinearity was checked using the variance inflation factor. Using a conservative threshold variance inflation factor value of 4, no collinearity was detected.  $p < 0.05$  was considered statistically significant. Survey design elements, including strata, cluster, and sampling weight, were applied in all analyses to account for complex sample design. All analyses were performed using SAS, version 9.4 (SAS Institute Inc.).

## RESULTS

Table 1 presents the descriptive characteristics of the study population. In total, 4384 women aged 15–49 years were included in the study and 1284 (25.8%) were anaemic. Most of the participants were aged 25–34 years (52.2%), were married/living with a partner (94.2%), were multipara (76.7%), had no formal education (53.9%) and were rural residents (82.3%). Additional characteristics of the study sample are shown in Table 1. Compared with women who have received nutritional counselling during ANC visits, a significantly higher proportion of women who have not received nutritional counselling were anaemic (23.1% vs. 30.8%;  $p < 0.001$ ). Additionally, the prevalence of anaemia differed by education, employment, household wealth index, residence, hormonal contraception and iron tablet use (Table 1).

Table 2 presents the multivariable-adjusted association between the characteristics of women and anaemia status. The odds of being anaemic were higher among women who did not receive nutritional counselling during their ANC visits compared with women who received nutritional counselling adjusted odds ratio (AOR) = 1.34 (95% CI = 1.07–1.67;  $p = 0.010$ ). Additionally, the odds of being anaemic were higher for women who reside in poor households compared with women who reside in rich households AOR = 1.44 (95% CI = 1.09–1.89;  $p = 0.009$ ). Compared with women who currently use hormonal contraception, the odds of being anaemic were higher among non-users AOR = 1.46 (95% CI = 1.17–1.82;  $p = 0.001$ ). Compared with women who were given or bought iron tablets, women who were not given iron tablets had higher odds of being anaemic AOR = 1.29 (95% CI = 1.07–1.55;  $p = 0.009$ ).

Table 3 presents the association between receipt of nutritional counselling and the presence of anaemia within subgroups of age, education, household wealth index and place of residence, respectively. Overall, consistent with the findings for the analytic sample, lack of nutritional counselling during ANC visits was associated with the presence of anaemia within these stratified subgroups also ( $p > 0.10$  for interaction in all subgroup analyses). However, some of the ORs failed to reach conventional levels of statistical significance as a



TABLE 1 Characteristics of the study sample ( $n = 4384$ )

	Overall <i>n</i> (wt.%)	Anaemic		<i>p</i>
		No <i>n</i> (wt.%)	Yes <i>n</i> (wt.%)	
Age (years)				0.666
15–24	1203 (26.2)	845 (74.9)	358 (25.1)	
25–34	2229 (52.2)	1579 (74.6)	650 (25.4)	
35–49	952 (21.6)	676 (72.6)	276 (27.4)	
Marital status				0.627
Never married	42 (0.9)	35 (83.4)	7 (16.6)	
Married/living together	4063 (94.2)	2861 (74.2)	1202 (25.8)	
Widowed/divorced/separated	279 (5.0)	204 (74.0)	75 (26.0)	
Parity				0.074
Primipara	1061 (23.3)	809 (77.3)	252 (22.7)	
Multipara	3323 (76.7)	2291 (73.3)	1032 (26.7)	
Currently pregnant				0.183
No	3990 (91.7)	2862 (74.6)	1136 (25.4)	
Yes	386 (8.3)	238 (70.2)	148 (29.8)	
Education				0.004
No education	2178 (53.9)	1435 (71.4)	743 (28.6)	
Primary	1454 (33.6)	1094 (77.5)	360 (22.5)	
Secondary or higher	752 (12.4)	571 (77.8)	181 (22.2)	
Employed				0.012
No	2939 (68.5)	1992 (72.5)	947 (27.5)	
Yes	1445 (31.5)	1108 (78.1)	337 (21.9)	
Wealth index				<0.001
Poor	1736 (36.4)	1092 (68.9)	644 (31.1)	
Middle	659 (21.0)	474 (73.5)	185 (26.5)	
Rich	1989 (42.6)	1534 (79.1)	455 (20.9)	
Residence				0.001
Urban	1250 (17.8)	967 (81.2)	283 (18.8)	
Rural	3134 (82.3)	2133 (72.7)	1001 (27.3)	
Body mass index				0.385
Underweight	930 (18.3)	613 (71.9)	317 (28.1)	
Normal	2914 (73.6)	2072 (74.5)	842 (25.5)	
Overweight/obese	540 (8.1)	415 (77.4)	125 (22.6)	
Number of antenatal care visit				0.285
1–3	2077 (53.1)	1314 (73.2)	655 (26.8)	
≥4	856 (19.8)	1786 (75.2)	629 (24.8)	

TABLE 1 (Continued)

	Overall <i>n</i> (wt.%)	Anaemic		<i>p</i>
		No <i>n</i> (wt.%)	Yes <i>n</i> (wt.%)	
Type of delivery				0.089
Vaginal	4165 (96.6)	2925 (74.0)	1240 (26.0)	
Caesarean	219 (3.4)	175 (81.6)	44 (18.4)	
Hormonal contraception use				<0.001
No	2721 (57.7)	1764 (70.3)	957 (29.7)	
Yes	1663 (42.3)	1336 (79.6)	327 (20.4)	
Deworming medication use				0.908
No	4035 (92.1)	2850 (74.2)	1185 (25.8)	
Yes	349 (7.9)	250 (74.6)	99 (25.4)	
Given or bought iron tablets				0.001
No	1574 (40.3)	1089 (70.7)	485 (29.3)	
Yes	2810 (59.7)	2011 (76.6)	799 (23.4)	
HIV test result				0.976
Negative	4315 (99.1)	3055 (74.2)	1260 (25.8)	
Positive	69 (0.9)	45 (74.5)	24 (25.5)	
Received nutritional counselling				<0.001
No	1460 (34.2)	933 (69.2)	527 (30.8)	
Yes	2924 (65.7)	2167 (76.9)	757 (23.1)	
Anaemia				
Not anaemic	3100 (74.2)			
Anaemic	1284 (25.8)			

Abbreviations: *n*: frequency, wt. %: weighted percent.

result of a reduction in sample size and inadequate statistical power within categories.

## DISCUSSION

The present study examined the relationship between receiving nutritional counselling during ANC visits and anaemia in a nationally representative sample of Ethiopian women of reproductive age. The prevalence of anaemia was higher among poor women, those who had not used hormonal contraceptives, those who did not receive or buy iron tablets and those who did not receive nutritional counselling. Controlling for potential confounders, lack of receipt of nutritional counselling during the ANC visit of the most recent birth significantly increased the likelihood of being anaemic. These results are consistent with existing literature about the importance of health education and introduce a new finding concerning the long-term impact of exposure to

TABLE 2 Crude and multivariable-adjusted associations between characteristics of women and anaemia ( $n = 4384$ )

	Crude OR (95% CI)	<i>p</i>	Adjusted OR (95% CI)	<i>p</i>
<b>Age (years)</b>				
15–24	Reference		Reference	
25–34	1.02 (0.81–1.28)	0.886	1.02 (0.78–1.35)	0.863
35–49	1.12 (0.85–1.49)	0.423	1.07 (0.76–1.52)	0.699
<b>Marital status</b>				
Never married	Reference		Reference	
Married/living together	1.74 (0.56–5.43)	0.338	1.75 (0.51–6.05)	0.376
Widowed/divorced/separated	1.76 (0.51–6.01)	0.368	1.69 (0.45–6.33)	0.439
<b>Parity</b>				
Primipara	Reference		Reference	
Multipara	1.24 (0.98–1.58)	0.077	1.09 (0.80–1.48)	0.593
<b>Currently pregnant</b>				
No	Reference		Reference	
Yes	1.25 (0.90–1.72)	0.182	1.02 (0.73–1.45)	0.891
<b>Education</b>				
No education	Reference		Reference	
Primary	0.72 (0.57–0.92)	0.007	0.83 (0.65–1.06)	0.142
Secondary or higher	0.71 (0.53–0.95)	0.022	1.26 (0.90–1.77)	0.171
<b>Employed</b>				
No	Reference		Reference	
Yes	0.74 (0.58–0.94)	0.012	0.79 (0.62–1.00)	0.051
<b>Wealth index</b>				
Poor	1.71 (1.33–2.19)	<0.001	1.44 (1.09–1.89)	0.009
Middle	1.37 (1.05–1.78)	0.019	1.18 (0.88–1.59)	0.276
Rich	Reference		Reference	
<b>Residence</b>				
Urban	Reference		Reference	
Rural	1.63 (1.22–2.16)	0.001	1.19 (0.83–1.73)	0.344
<b>Body mass index</b>				
Underweight	Reference		Reference	
Normal	1.14 (0.87–1.51)	0.350	1.13 (0.85–1.49)	0.397
Overweight/obese	0.85 (0.59–1.23)	0.388	1.00 (0.69–1.46)	0.992
<b>Number of antenatal care visit</b>				
1–3	Reference		Reference	
≥4	0.90 (0.75–1.09)	0.287	1.08 (0.88–1.33)	0.447
<b>Type of delivery</b>				
Vaginal	Reference		Reference	
Caesarean	0.64 (0.38–1.08)	0.093	0.86 (0.49–1.49)	0.587

(Continues)

TABLE 2 (Continued)

	Crude OR (95% CI)	<i>p</i>	Adjusted OR (95% CI)	<i>p</i>
<b>Hormonal contraception use</b>				
No	1.65 (1.34–2.03)	<0.001	1.46 (1.17–1.82)	0.001
Yes	Reference		Reference	
<b>Deworming medication use</b>				
No	Reference		Reference	
Yes	0.98 (0.66–1.46)	0.908	1.15 (0.78–1.68)	0.482
<b>Given or bought iron tablets</b>				
No	1.36 (1.13–1.62)	0.001	1.29 (1.07–1.55)	0.009
Yes	Reference		Reference	
<b>HIV test result</b>				
Negative	Reference		Reference	
Positive	0.99 (0.37–2.62)	0.976	1.19 (0.47–2.99)	0.712
<b>Received nutritional counselling</b>				
No	Reference		Reference	
Yes	1.48 (1.19–1.84)	<0.001	1.34 (1.07–1.67)	0.010

Abbreviations: CI, confidence interval; OR, odds ratio.

nutritional counselling during ANC on anaemia status after giving birth.

Although the prevalence of anaemia was mild in the population, it still requires the attention of public health experts. It necessitates debunking the misconception surrounding the disease that equates anaemia with iron deficiency by explaining the disease's multiple nutritional, social, environmental, biological and behavioural determinants.<sup>33</sup> Recognising the complexity of the disease aetiology is essential in the development of evidence-based and multisectoral programs for preventing anaemia. This would be important given that reducing the burden of the disease in a population will enhance pregnancy outcomes, child health, women's work productivity, children's school performance and intergenerational health.<sup>33</sup>

In the present study, women who did not receive nutritional counselling at their most recent ANC visit were more likely to be anaemic. A plausible explanation for the observed association is that pregnant women who received the proper dietary education during their ANC visits continued using the information to modify their diet and take iron supplements to lower their risk of anaemia. Healthcare providers should recognise the long-term benefit of nutritional counselling during ANC visits because it has the potential to empower and motivate women to adopt a healthy lifestyle. Most importantly, providers should recognise how different the nutritional needs of pregnant women are from that of non-pregnant women and tailor their nutritional

counselling accordingly. This entails acknowledging cultural differences, socioeconomic backgrounds, physiological conditions and access to food.<sup>34</sup>

Other factors associated with anaemia include iron supplement intake, household wealth index and hormonal contraception use. The present study demonstrated that women who did not use iron supplements during their most recent pregnancy were more likely to be anaemic. Healthcare providers have routinely recommended iron-containing supplements for all women of reproductive age, especially where anaemia is prevalent.<sup>33</sup> However, women have not always been compliant because of side effects that come with the supplements, such as nausea, constipation and stomach pain.<sup>34</sup> Future interventions should include educating pregnant women about dietary sources of iron, the benefits of iron supplements and the importance of vitamin C supplements that enhance iron absorption. Pregnant women also need to be taught how to counter the side effects of the supplements.

Furthermore, poor women were more likely to be anaemic compared with their counterparts. This shows how socio-economic factors beyond nutrition significantly contribute to the burden of the disease. Poverty might be related to poor dietary intake, food insecurity and taboos against eating iron-rich foods. It might also be associated with limited access to nutritional information or iron-rich foods. Multiple studies from the developing world have shown a strong association between women's empowerment and maternal and child

**TABLE 3** Multivariable-adjusted associations between receipt of nutritional counselling and anaemia stratified by age, education and household wealth index

	Received nutritional counselling	AOR (95% CI)	<i>p</i>	<i>p</i> for interaction
Age (years) <sup>a</sup>				0.426
18–24	Yes	[Reference]		
	No	1.75 (1.14–2.70)	0.011	
25–34	Yes	[Reference]		
	No	1.28 (0.94–1.76)	0.122	
35–49	Yes	[Reference]		
	No	1.17 (0.74–1.86)	0.501	
Education <sup>b</sup>				0.693
None	Yes	[Reference]		
	No	1.38 (1.05–1.80)	0.020	
Primary	Yes	[Reference]		
	No	1.54 (1.06–2.23)	0.025	
Secondary or higher	Yes	[Reference]		
	No	1.26 (0.61–2.59)	0.533	
Household wealth index <sup>c</sup>				0.175
Poor	Yes	[Reference]		
	No	1.24 (0.91–1.70)	0.177	
Middle	Yes	[Reference]		
	No	1.13 (0.72–1.79)	0.598	
Rich	Yes	[Reference]		
	No	1.85 (1.30–2.64)	<0.001	

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.

<sup>a</sup>Model adjusted for marital status, parity, currently pregnant, education, employment, household wealth index, residence, body mass index (BMI), number of antenatal care visits, type of delivery, hormonal contraception use, deworming medication use, given or bought iron tablets and HIV test result.

<sup>b</sup>Model adjusted for age, marital status, parity, currently pregnant, employment, household wealth index, residence, BMI, number of antenatal care visits, type of delivery, hormonal contraception use, deworming medication use, given or bought iron tablets and HIV test result.

<sup>c</sup>Model adjusted for age, marital status, parity, currently pregnant, education, employment, residence, BMI, number of antenatal care visits, type of delivery, hormonal contraception use, deworming medication use, given or bought iron tablets and HIV test result.

health outcomes, including nutritional status and dietary diversity.<sup>35–37</sup> Although the lack of a standardised measure for women's empowerment remains a major challenge, it has been identified as a feasible pathway to improve maternal and child nutrition outcomes.<sup>37,38</sup> Future interventions should consider enhancing women's economic power through microfinance-based interventions and direct cash transfers.

Women who did not use hormonal contraceptives were more likely to be anaemic. This may be due to heavy menstrual bleeding (HMB) that could result in loss of iron.<sup>39</sup> Although the clinical diagnosis is subjective and does not involve the measurement of actual blood loss, HMB is commonly defined as menstrual flow exceeding 80 ml of blood loss per mensural cycle that cannot be explained by a medical illness or organic

pathology.<sup>40</sup> A recent randomised control trial has demonstrated how combined oral contraceptives significantly reduced HMB in the intervention group compared to placebo.<sup>41</sup> Accordingly, future interventions should consider teaching the non-contraceptive benefits of hormonal and intrauterine reversible contraceptive methods on HMB, including endometriosis, ectopic pregnancy and premenstrual dysphoric disorder.<sup>40</sup>

The present study should be interpreted within the context of its limitations. First, because the study was cross-sectional, establishing a causal inference is impossible. Second, although the most common micronutrient deficiency related to anaemia is iron deficiency, other less common micronutrient deficiencies (vitamin A, B<sub>2</sub>, B<sub>6</sub>, B<sub>9</sub>, B<sub>12</sub>, C, D and E, as well as copper and zinc) that are known to cause or contribute to anaemia were

not included in the analysis. Third, environmental factors that contribute to anaemia, such as access to clean water, sanitation and hygiene, were not included in the analysis. Fourth, the EDHS dataset did not capture exposure to malaria and parasites such as soil-transmitted helminths and schistosomiasis that contribute to anaemia. Fifth, data on the quality of nutritional counselling received during ANC were not captured in the EDHS. Further studies should be conducted to investigate what type of information is provided during the ANC encounter and how it is delivered. Sixth, self-reported data on receipt of nutritional counselling during ANC is susceptible to recall and social desirability biases. The study's main strengths include the large sample size and the inclusion of key potential confounders in the multivariable logistic regression model. Additionally, all data were collected using a well-established, standardised and rigorous methodology implemented by the DHS program.

## CONCLUSIONS

In a representative cross-sectional sample of Ethiopian women, a strong positive association was found between lack of nutritional counselling during ANC visits and anaemia. Anaemia remains a public health challenge in Ethiopia, mainly affecting women of reproductive age and children. The present study highlights the importance of health education during ANC visits in reducing the risk of anaemia long after pregnancy. More focus should be given to improving the quality of the ANC encounter and providing focused ANC counselling services. Educating pregnant women about diet modification and the importance of vitamin and mineral supplements can reduce the incidence of anaemia in the long run. The findings from this study suggest that improved access to nutritional counselling during ANC visits can be an effective strategy to prevent anaemia among women.

## AUTHOR CONTRIBUTIONS

Eden Taddese participated in the study conception, data analysis and interpretation and also drafted the manuscript. Dawit G. Alemu participated in the planning of data analysis, interpretation of results and substantial editing of the manuscript. Mohammad R. Haider participated in data interpretation and critical review of the manuscript. Zelalem T. Haile conceptualised the project, supervised the data analysis, and assisted in reviewing and revising the manuscript. All authors read and approved the final version of the manuscript submitted for publication.

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## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines.

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# Using social media analysis to study population dietary behaviours: A scoping review

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## Abstract

**Background:** The rapid adoption and sustained use of social media globally has provided researchers with access to unprecedented quantities of low-latency data at minimal costs. This may be of particular interest to nutrition research because food is frequently posted about and discussed on social media platforms. This scoping review investigates the ways in which social media is being used to understand population food consumption, attitudes and behaviours.

**Methods:** The peer-reviewed literature was searched from 2003 to 2021 using four electronic databases.

**Results:** The review identified 71 eligible studies from 25 countries. Two-thirds ( $n = 47$ ) were published within the last 5 years. The USA had the highest research output (31%,  $n = 22$ ) and Twitter was the most used platform (41%,  $n = 29$ ). A diverse range of dataset sizes were used, with some studies relying on manual techniques to collect and analyse data, whereas others required the use of advanced software technology. Most studies were conducted by disciplines outside health, with only two studies (3%) being conducted by nutritionists.

**Conclusions:** It appears the development of methodological and ethical frameworks as well as partnerships between experts in nutrition and information technology may be required to advance the field in nutrition research. Moving beyond traditional methods of dietary data collection may prove social media as a useful adjunct to inform recommended dietary practices and food policies.

## KEYWORDS

dietary assessment, dietary behaviour, food attitudes, food consumption, nutrition, social media analysis

## Key points

- The use of social media analysis for nutrition research has grown significantly in the last 5 years and may prove as a useful adjunct to inform recommended dietary practices and food policies.
- Most studies were conducted by researchers from non-health disciplines such as IT and business, highlighting an opportunity for cross-disciplinary collaborations with nutrition researchers.
- The development of methodological and ethical frameworks for social media analysis is needed to increase the academic rigour of studies and support future research.

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## INTRODUCTION

The rise of social media has been regarded as one of the distinguishing features of the digital technological revolution.<sup>1</sup> It is estimated that, in January 2022, there were approximately 4.62 billion social media users globally, equating to 58% of the world's total population.<sup>2</sup> Social media can be defined as a medium that allows users to generate and exchange content amongst a social network of other users.<sup>3</sup> Although often associated with mainstream social networking applications such as Facebook and Instagram, social media can take a wide variety of forms, including blogs, forums, image and video sharing services, online review websites, social bookmarking websites, collaborative projects, corporate networks, online gaming and virtual reality worlds.<sup>4</sup>

Social media analysis has generated substantial interest among researchers across a wide variety of disciplines for its ability to provide large quantities of global data at a substantially reduced cost compared to traditional methods such as surveys and questionnaires,<sup>5</sup> which also carry the risk of selection bias, recall bias and reactivity bias.<sup>6</sup> Social media also has the advantage of offering low latency data, allowing users to be observed in real time, creating opportunities for both continual analysis and temporally granular post-event analysis.<sup>6</sup> Social media analysis does however face the ongoing challenge of filtering out high volumes of spam and falsified data.<sup>7</sup> It can also be impacted by biases including sampling bias where users who are tech savvy are overrepresented<sup>8</sup> as well as social desirability bias as users often seek social approval for content posted.<sup>9</sup>

Data from social media can be collected and interpreted in a variety of ways. Small-scale studies can be undertaken by researchers independently using manual scraping, coding and thematic analysis with or without statistical analysis<sup>10,11</sup> and large-scale studies can be undertaken using automated content analysis involving sophisticated data scraping tools, natural language processing software, image-recognition software and computational statistical analysis.<sup>12,13</sup>

The use of advanced analytic software has become increasingly popular as new technologies and social media surveillance services continue to emerge.<sup>14</sup> These services often rely on collecting social media data through an application program interface (API), where social media platforms allow a sub-sample of their data to be accessed by third parties, usually at a cost.<sup>14</sup> The subsequent process of analysis varies between services and on the desired outcome but often includes processes such as tokenisation, Latent Dirichlet Allocation, Principal Component Analysis, Support Vector Machines and statistical analysis.<sup>15</sup>

There are advantages and disadvantages to both manual and automated forms of social media analysis. Manual content analysis allows the researcher to remain intimately connected to the data and provide contextual

insights during the analytic process, but it is labour intensive and subject to researcher biases and coding errors.<sup>16</sup> However, although automated analysis can overcome some of these limitations, miscategorisation of data is commonly observed as many commercial algorithms are not used for their intended purpose and must be continually updated to detect nuances in language and adapt to the constant evolution of human communication.<sup>17</sup> Additionally, there are a range of ethical concerns associated with researchers using publicly available data which does not require user consent. Such concerns include the invasion of user privacy where users are not aware of how their data is being used, the potential reidentification of data by triangulating anonymous data with publicly available information to identify the original user and the potential for researchers to profile users according to race, gender, ethnicity or economic status and then target those users with misleading information.<sup>18</sup>

The applications for social media analysis are seen in a variety of industries including healthcare, marketing, politics, sports, media, finance and agriculture.<sup>19</sup> It is commonly used to gain insights on population attitudes and behaviours as well as gain feedback for a particular product or service.<sup>20,21</sup> Studies have also demonstrated the predictive power of social media analysis which, for example, can be used to forecast public attendance of major events and predict election outcomes.<sup>22,23</sup> Not only is social media analysis useful for gaining insights at a population level, but also it is useful for identifying and characterising the key players and users of influence who are driving attitudes and behavioural trends forward.<sup>7</sup>

In the area of nutrition, social media is particularly rich with data on food consumption patterns and behaviours because users are frequently exposed to food-related content from peers, or through marketing posts from food brands active on social media.<sup>24</sup> However, despite an abundance of available data, the extent to which this data is being used is still largely unknown and literature reviews mapping and evaluating the different methodologies and applications for social media analysis in the context of nutrition are sparse.

A prior review explored the use of social media analysis in 34 studies published 2014–2020 that investigated dietary behaviours using datasets of between four million and eight million posts, requiring the use of sophisticated analytical tools.<sup>25</sup> However, as outlined previously, this is not the only potential application for social media analytics because it can also be used to provide meaningful insights in smaller scale studies using manual scraping, coding and thematic analysis in data sets of less than 100 posts.<sup>10,11</sup>

This scoping review aims to map existing studies that have used both manual and automated social media analysis to investigate food consumption and dietary behaviours of groups, communities and populations. The review considers the diversity of social

media platforms used, the different methodologies and programs used to collect, analyse and validate data, the size and specificity of each study, as well as the disciplines involved in conducting each study. By including smaller studies from the emergence of mainstream social media in 2003 onwards, this scoping review will also provide insights for researchers interested in approaches to social media analysis of food and beverage behaviours that do not rely on sophisticated computer programs.

## METHODS

The scoping review protocol was developed in accordance with the updated Joanna Briggs Institute (JBI) recommendations for scoping reviews found in Chapter 11 of the *JBI Manual for Evidence Synthesis*,<sup>26</sup> and the Arksey and O'Malley five-step framework.<sup>27</sup> The study is presented in accordance with the PRISMA-SCr reporting guidelines<sup>28</sup> and due attention was also paid to the PRISMA 2020 Checklist,<sup>29</sup> for any additional reporting guidelines of relevance. The protocol is published in the Open Science Framework.<sup>30</sup>

### Inclusion criteria

The inclusion criteria for this review was developed using the structure of Participants, Concept and Context as recommended by the *JBI Manual for Evidence Synthesis*.<sup>26</sup>

### Participants

This review sought to identify existing studies and subsequently evaluate their quality, methodological framework and the nutrition topics of interest. Because this aim was largely exploratory, no limitations around the inclusion or exclusion of specific population subgroups were used. Instead, the logic was that leaving this variable open (when conducting the literature search) would provide a clearer picture of the breadth of the current evidence, in turn allowing for specific population groups to be identified for future research. However, studies that investigated marketing or promotional content from companies, organisations or lobbying groups on social media were excluded because the views of their study populations were deemed unrepresentative of the general population. Similarly, users with a large social following (more than 50,000 followers) or with a celebrity-like public image (i.e., accounts with verified badges) were also excluded because content from these users may be influenced by endorsements and other commercial incentives rather than serving as a depiction of their usual dietary patterns.

## Concept

This review mapped studies that used publicly available data from popular social media platforms to gain insight about the food consumption patterns and behaviours of groups, communities and populations. Social media was considered to be any online platform that allowed users to generate and exchange content including both conventional social media platforms like Facebook and Instagram as well as non-conventional social media platforms such as blogs, forums, image and video sharing services, online review websites, social bookmarking websites, collaborative projects, corporate networks, online gaming and virtual reality worlds.<sup>4</sup> Valid forms of user data included text, images, captions, likes/reactions, geolocations or any combination of these measures. Studies that used data obtained from static commercial websites or from interventions designed to investigate the impact of social media on dietary behaviours were not considered.

## Context

Social media content relating specifically to diet including food and beverage intake, food preferences, eating behaviours and use of nutritional supplements were included. This included studies that investigated multiple health related factors (e.g., physical activity, diet and mental health) and, in these instances, the relevant data on diet was extracted and charted. Studies investigating broader lifestyle interventions, food industry logistics, weight loss, breastfeeding practices, alcohol, illicit drugs, cigarettes or nicotine replacement therapy, support for diagnosed eating disorders or opinions on nutrition-related diseases such as malnutrition or coeliac disease were not included.

## Types of studies

This scoping review investigated both cross-sectional and cohort studies from peer-reviewed literature. Grey literature, abstracts, commentaries, books and other reviews were not included. Only studies published in English from 2003 onwards (the creation of Myspace and onset of mainstream social media) were included.

## Search strategy

A preliminary search was undertaken using the Medline via ovid 1946–present database to identify relevant studies. The titles and abstracts of the identified studies were examined to obtain keywords for the comprehensive search strategy. The comprehensive search was



conducted using four databases (see section below on Information sources) and modified *post hoc* as necessary. Additionally, the reference lists of studies selected for full-text review were examined to ensure that no relevant papers had been missed. A copy of the search strategy for one database, Medline, is provided in the Supporting information (Appendix 1).

## Information sources

The comprehensive search strategy was conducted by searching the databases CINAHL, SCOPUS, PsychInfo and Medline using the identified keywords and an iterative process of adjustment to the search as required to maximise literature captured. The reference lists of studies selected for full-text review were also screened to identify additional papers. Google was used to verify author credentials when author location or discipline was not clearly documented.

## Selection process

Records were pooled via EndNote 20 (<https://endnote.com>) and duplicates were removed. Two of the reviewers (JT and GC) independently reviewed the titles and abstracts of the results against the eligibility criteria. Studies meeting the criteria were retrieved in full-text and the remaining studies were excluded. Both reviewers independently screened the full text studies and charted eligible studies in a data charting form. Studies that did not meet the eligibility criteria had the reason for

exclusion recorded and presented in diagrammatic form (Figure 1). Disagreements between the reviewers were resolved through input from a third reviewer (MA-F) as needed.

## Data charting

A data charting form was developed and formulated using the JBI framework for data extraction.<sup>26</sup> The charting form extracted first author, title, year of publication, study location, social media platform(s), study population(s), nutrition topic(s) studied, outcome measures (user responses such as comments, tweets, likes, etc.), size of data set, methods of data collection, methods of data analysis and programs or algorithms used. A second charting form was subsequently developed extracting additional information including geographical region of each study location, research discipline, specificity of research topic and method of validation.

## Synthesis of results

Characteristics of the data from the charting form were tabulated (Table 1) with study references (author, publication date, country) in the first column followed by the social media platform(s) investigated, the study population(s), the nutrition topic(s) studied, the user response measured (e.g., likes, comments, shares), the dataset size, the method of data collection and the method of data analysis. Further study characteristics

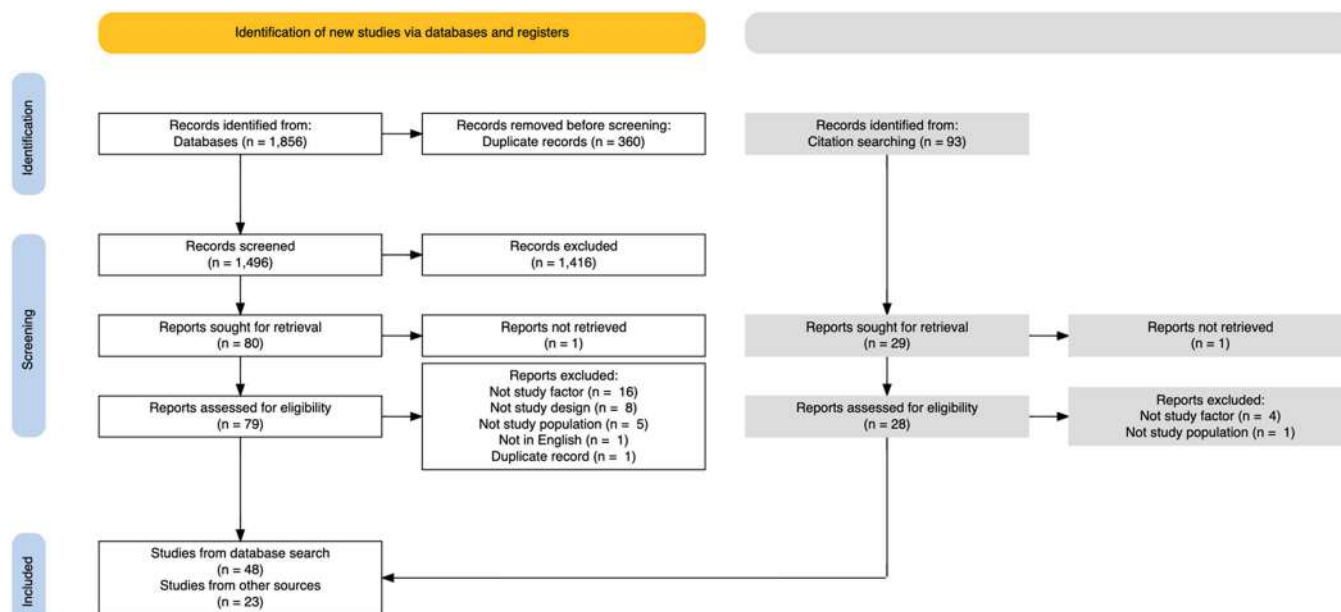


FIGURE 1 PRISMA flowchart outlining the identification and inclusion of studies. \*Flowchart generated online using the R package ShinyApp (<https://shiny.rstudio.com>)<sup>31</sup>



TABLE 1 Characteristics of included studies

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
1 Abbar et al. (2015) Qatar	Twitter	Twitter users located in the United States at time of tweeting about food ( $n = 210\text{ K}$ )	Food consumption patterns and their relationship to obesity rates	Tweets	50 M tweets	Twitter API	Natural language processing Linguistic inquiry and word count (LIWC) lexicon Statistical analysis Pearson correlation Spearman correlation Bootstrap test	CrowdFlower WeFollow Gendrise API Text classifier (unnamed)
2 Amson et al. (2021) Canada	Facebook, Instagram, Twitter & Twitter	Attendees and suppliers of the Winterlude family-friendly event that posted about the event on Facebook, Twitter or Instagram	Food and beverage consumption patterns at a family friendly event	Tweets, Facebook posts and Instagram posts (including story high-lights)	732 posts	Manual scraping (searches using hashtags and supplier profiles)	Content analysis Statistical analysis $\chi^2$ tests Fisher's exact tests with Freeman–Halton extension Pairwise comparisons with Bonferroni corrections	SPSS, version 26.0 SAS, version 9.4
3 Eriksson-Backa et al. (2016) Finland	Twitter	Twitter users ( $n = 6116$ )	Attitudes and perceptions of food relating to diet and diabetes	Tweets	9042 tweets	Twitter API (using Webometric Analyst)	Natural language processing (semantic content analysis)	Webometric Analyst VOSviewer Gephi
4 Blackburn et al. (2018) United States	Reddit	Reddit users engaged in the <i>r/food</i> and <i>r/food 2</i> subreddit forums	Attitudes/perceptions of foods, recipe sharing, cooking methods and cultural influences	Posts and comments, Images and links not included.	290,223 text observations	Reddit API (using a script developed by first author)	Natural language processing (linguistic analysis) Principal component analysis (PCA) with Varimax rotation Statistical analysis Welch's <i>t</i> tests	Meaning Extraction Helper (MEH)
5 Chen et al. (2014) United States	Twitter	Twitter users tweeting from Columbus (OH, USA)	Food consumption patterns to map food environments	Tweets – geotagged	81,543 tweets	Other – streamed from an open source python library	Content analysis Statistical analysis Frequency counts One-way ANOVA test	An open source Python library ESRI ArcMap 10.2

(Continues)

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
6 Danner et al. (2020) Germany	Other – News websites and forums	Individuals from either the United States or German-speaking countries engaged in discussions on news websites and forums	Attitudes/perceptions of organic food	Comments	2163 comments	Manual scraping (search of threads using keywords and random textual sampling)	Natural language processing (topic modelling) Latent Dirichlet allocation (LDA) PCA Support Vector Machine (SVM) Statistical analysis Frequency counts Global $\chi^2$ test Cohen's Kappa Kruskal –Wallis one-way analysis of variance test Error analysis	MAXQDA 12 Python Gensim library
7 De Choudhury et al. (2016) United States	Instagram	English-speaking Instagram users ( $n = 8$ M)	Food consumption patterns and nutrition quality in order to map food environments	Images and captions	3 M geotagged posts	Instagram API Federal Communications Commission API for latitude-longitude pairing of each post	Natural language processing (topic modelling) LDA Statistical analysis $k$ nearest neighbours algorithm Independent sample $t$ -test Mahalanobis distance metric	Python Gensim library
8 Dixon et al. (2012) The Netherlands	Twitter	English speaking twitter users	Food consumption patterns and their relationship to emotional health and obesity rates	Tweets – geo-tagged	3668 food items detected in tweets	Twitter API (using FoodMood) Bing API	Natural language processing (sentiment analysis) Pointwise mutual information method (PMI) Bayesian sentiment classifier	FoodMood
9 Dondokova et al. (2019) South Korea	Twitter	Twitter users	Food consumption patterns and eating	Tweets	59,177 tweets	Twitter API	Natural language processing TF-IDF weighting method	R

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
10 Fried et al. (2014) United States	Twitter	Twitter users located in the United States at time of tweeting	behaviours at breakfast, lunch, dinner and snack/snacking Food consumption patterns and ability to predict health status and location using food tweets	Tweets	>3 M tweets	Twitter API (using Lucene-backed Solr instance)	<i>n</i> -gram based text analysis Statistical analysis Frequency counts	Solr Instance Stanford CoreNLP MALLET
11 Ghosh et al. (2013) United States	Twitter	Twitter users located in the United States at time of tweeting	Food consumption patterns and their relationship to obesity rates and the food environment	Tweets	455,981 geotagged tweets	Twitter API	Natural language processing (topic modeling) Tokenisation LDA Spatial and statistical analysis Z-scores <i>p</i> -values	Geographic Information System (GIS) ESRI ArcGIS 10.0 (ESRI 2012) R 2.15.1 Porter stemming algorithm
12 Gore et al. (2015) United States	Twitter	Twitter users located in the United States at time of tweeting	Food consumption patterns and their relationship to obesity rates and the food environment	Tweets – geotagged (excluding retweets)	>25 M geotagged tweets	Twitter API	Statistical analysis Spearman correlations Various equations Other Nutrient-rich foods index (NRF) formula	Unspecified algorithms
13 Holmberg et al. (2016) Sweden	Instagram	Adolescent Instagram users ( <i>n</i> = 1001) posting about food with the hashtag #14ar (14years) included	Food consumption patterns	Images	854 images	Other – Statigram	Content analysis	Statigram

(Continues)

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
14 Hsieh et al. (2021) Taiwan	Other – icook.tw (the largest Chinese recipe sharing website in Taiwan)	Users of icook.tw	Nutritional quality of recipes shared socially online	Other – Recipes shared	15,303 recipes	Other – Machine learning used to extract and classify data	Natural language processing Frequency counts Cluster analysis SVM Naive Bayes decision tree Macro-average F1-score TF-idf model	
15 Jalal et al. (2019) Kenya	Instagram	Instagram users in Kenya for dataset a) and Instagram users posting about Kenyan foods from any location in dataset b)	Food consumption patterns in Kenya and consumption of Kenyan food globally	Images and captions	3,56 M images (dataset a) and ~30,000 images (dataset b)	Instagram API	Deep learning (multi-model deep neural networks) Statistical analysis	Kenyan Food Classify (KenyanFC) KenyanFood13 Pre-trained BERT model ResNeXt101 model pretrained on ImageNet dataset YOLO v3 algorithm pretrained on MSCOCO Food-5K and FCD datasets for training and testing
16 Justo et al. (2018) Brazil	Pintrest	Pintrests users	Attitudes, perceptions and consumption of functional foods promoted for cancer	Pins, likes, reprints and shares	75 pins	Manual scraping (searching in Pintrest using 'cancer' and selecting food related results)	Content analysis Frequency counts	Microsoft Excel
17 Karami et al. (2021) United States	Twitter	Twitter users located in the United States at time of tweeting	Food consumption patterns in relation to political orientation	Tweets	875,277 geotagged tweets	Twitter API	Natural language processing (topic modelling) Some manual coding C.V method LDA Statistical analysis ANOVA test Turkey's multiple comparison test	Gensim Python MALLET FiveThirtyEight R

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
18 Khan et al. (2019) New Zealand	Facebook, Instagram, Twitter and <a href="http://Sikayetvar.com">Sikayetvar.com</a>	Facebook, Instagram, Twitter and <a href="http://Sikayetvar.com">Sikayetvar.com</a> users (a Turkish review/complaints website)	Anti-consumption of fast foods (fast food avoidance)	Comments	1153 comments	Manual scraping (downloading from website)	Content analysis	Keras
19 Khulbe et al. (2019) United States	Instagram, Yelp	Yelp and Instagram users located in the Manhattan borough of New York City at the time of posting	Food consumption trends and popularity of cuisine types	Images, captions	85,000 images	Yelp API and Instagram scraper ( <a href="https://github.com/arc298/instagram-instagram-scraper">https://github.com/arc298/instagram-instagram-scraper</a> )	Deep learning Kernel density estimation (KDE) model Bayesian Networks with BIC scoring method using the Greedy Hill Climbing approach ResNet-50 model Stochastic Gradient Descent (SGD) optimiser Directed Acyclic Graph (DAG)	
20 Koball et al. (2018) United States	Facebook	Facebook users seeking support on Facebook following Bariatric surgery	Food consumption and behaviours following bariatric surgery (secondary outcome of the study)	Posts	> 10,000 posts collected reduced to 315 for content analysis	Manual scraping (searching of Bariatric Facebook Groups)	Manual thematic analysis (using Grounded-theory approach) Statistical analysis Frequency counts Two-sample Z-scores with Yates continuity correction and Bonferroni adjusted alpha-level	
21 Laestadius et al. (2015) United States	Other – News websites (The New York Times, The Los Angeles Times,	462 online commentators (people who had commented on one of more of the news sites)	Attitudes/perceptions of in vitro meat	Comments	814 comments	Manual scraping (searches of websites using keywords)	Manual thematic analysis (using deductive and inductive approach)	Microsoft Excel HyperRESEARCH 3.5.2

(Continues)



TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
	The Washington Post, The Wall Street Journal, USA Today, Cable News Network and National Public Radio)							
22 Leipämaa-Leskinen et al. (2018) Finland	Other – News websites, online discussion forums, blogs and printed articles	Online commentators or authors discussing horsemeat perceptions and consumption in Finnish media	Attitudes/perceptions of horsemeat	Other – Media texts from online news websites, online discussion forums, blog postings and printed articles	55 Finnish online news items, threads in 7 Finnish online discussion forums, 7 blog postings and attached discussions, 4 printed articles from Finnish horse magazines and newspapers that specifically discussed horsemeat	Manual scraping (purposive sampling using keywords in Google search engine)	Content analysis Emic-based descriptions Structural analysis Greimas' semiotic square	
23 Liang et al. (2019) United States	Twitter	Twitter users located in both San Diego and Houston (study 2)	Food consumption patterns and their relationship to obesity rates	Tweets – geotagged (study 2)	7291 tweets	Twitter API (using SMART dashboard)	Natural language processing (topic modelling) LDA Statistical analysis Frequency counts Z-test	R
24 Lynch et al. (2018) Canada	Other – blogs	Young female bloggers > 19 yrs old	Attitudes/perceptions and behaviours promoted by food bloggers	Blogs	45 blogs	Manual scraping (purposive sampling using keywords 'healthy food blog' in Google search engine)	Content analysis	

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
25 Lynch et al. (2019) Canada	Facebook and CBC.ca (Canadian online news website)	News and Facebook commentors in proximity to the Yellowknife, Northwest Territories region in Canada discussing the closure of a local KFC restaurant ( $n = 239$ )	Attitudes/perceptions of KFC closure	Comments and comment replies	308 comments	Manual scraping (collection of comments and comment replies from relevant articles posted on CBC.ca website and Facebook page captured using NCapture from Nvivo)	Content analysis	NCapture NVivo
26 Lynn, et al. (2018) Ireland	Twitter	English speaking twitter users using the phrase 'healthy diet' or #healthydiet ( $n = 629,608$ )	Attitudes/perceptions of a healthy diet	Tweets	1,212,318 tweets	Twitter API (GNIP)	Natural language processing (topic modelling) Lexicon based approach Machine learning Statistical analysis Frequency counts	IUNI Botometer
27 Mejova et al. (2015) Qatar	Instagram and Foursquare	Instagram users from 316 countries ( $n = 3,367,777$ )	Food consumption patterns, attitudes and behaviours in relation to dining experiences, social approval of diet and obesity rates	Images, captions and Foursquare check-ins (via Instagram)	20,848,190 posts	Foursquare API and Instagram Location Endpoints API	Natural language processing Statistical analysis Pearson correlations Spearman's rank correlations	CrowdFlower9
28 Mejova et al. (2016) Qatar	Instagram	Worldwide Instagram users using the hashtags #foodporn, #instagood or #food	Food consumption patterns, attitudes and behaviours	Images and captions (primary dataset), Tweets (secondary dataset for comparison)	9,378,193 posts	Instagram API Geolocation data obtained via World Borders shape file2	Natural language processing Some manual labelling Statistical analysis Frequency counts Pearson correlation	Crowdflower4 Google Translate World Borders shape file2

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TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
30 Money et al. (2020) United States	Reddit	English speaking Reddit users	Seasonal food consumption patterns, perceptions and attitudes toward food	Posts and comments	527,726 posts	Other – Crimson Hexagon + Brandwatch using the keyword 'diet'	Natural language processing (topic modelling) LDA C_V method Some manual coding Statistical analysis Frequency counts Shapiro-Wilk normality test Wilcoxon test	Python Genism Mallet
31 Mostafa (2018) Kuwait	Twitter	English speaking Twitter users using the phrase #halal	Attitudes/perceptions of Halal food	Tweets	100,000 tweets	Manual scraping (keyword searching twitter for the term halal food). Study does not mention whether Twitter API was used.	Natural language processing (polarity analysis) Statistical analysis Inter-rater percentage agreement Krippendorff's Alpha	SentiStrength QDA Miner 5.0 R 3.4
32 Moura et al. (2021) Denmark	Facebook	Danish and French speaking parents	Attitudes/perceptions of sugar	Posts and comments	59,854 words from France and 41,232 words from Denmark	Manual scraping (keyword searching in groups)	Manual thematic analysis (using inductive and deductive approach)	NVivo
33 Närvänen et al. (2013) Finland	Finnish online conversation boards	Online users posting on Finnish conversation boards	Attitudes/perceptions and behaviours in relation to convenience food	Posts and comments	1331 posts/comments	Manual scraping (theoretical sampling of discussion chains downloaded from the Internet)	Manual thematic analysis (using 'Practice-theory' approach)	
34 Närvänen et al. (2013) Finland	Other – Karppaus.info (a Finnish online community for LCHF dieters)	Users of Karppaus.info	Attitudes, perceptions and behaviours of individuals following a Low Carb High Fat (Keto) diet	Posts and comments	Not specified	Manual scraping (theoretical sampling of discussion chains)	Manual thematic analysis (using sensitising concepts from previous research)	

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
35 Nguyen et al. (2016) United States	Twitter	English-speaking, American Twitter users located in Salt Lake, San Francisco or New York	Food consumption patterns in relation to happiness, physical activity and socio-economic factors	Tweets	2.8 M tweets	Twitter API	Natural language processing (sentiment analysis) Tokenisation R-tree Statistical analysis Frequency counts Kappa statistics	Python PTB Tokeniser LabMT Bag-of-words algorithm
36 Nguyen et al. (2017) United States	Twitter, Yelp	American Twitter and Yelp users, communicating to their social network about food or a food location.	Food consumption patterns and associations between state food environments and health status	Tweets, Yelp reviews	4,041,521 geotagged tweets and 505,554 food-related businesses (from Yelp)	Twitter API, Yelp API	Natural language processing (sentiment analysis) R-tree Statistical analysis	Python Mallet Stata MP13
37 Nguyen et al. (2017) United States	Twitter	Twitter users from Utah aged 20+, tweeting about food	Food consumption and nutritional quality and its relationship to neighbourhood characteristics and chronic disease	Tweets – geotagged	422,094 tweets	Twitter API	Natural language processing (sentiment analysis) Statistical analysis Linear regression Log Poisson Regression	Python 2.7.12 ArcGIS Desktop, version 10.5 Mallet Stata MP13
38 Phan et al. (2017) Switzerland	Instagram, Foursquare	Swiss users using Foursquare food venue check ins and posting on Instagram using at least one food-related hashtag	Food and drink consumption patterns and eating behaviours (meal time & location)	Images, captions, check-ins	1.7 M Instagram posts	Instagram API, Foursquare Venue API	Manual thematic analysis Natural language processing Co-occurrence Bhattacharyya distributional distance Random Forest	Face ++ API

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TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
39 Pila et al. (2017) United States	Instagram	English-speaking Instagram users posting using the hashtag #cheatmeals	Food consumption and behaviours in relation to cheat meals	Images and captions	600 images	Instagram API (using Talkwalker website)	Manual thematic analysis Inductive content analysis Statistical analysis $\chi^2$ test	Talkwalker
40 Pilar et al. (2018) Czech Republic	Instagram	English-speaking Instagram users posting using the hashtag #farmersmarket	Attitudes/perceptions of foods sold at farmers markets	Images and captions	19,398 posts	Other – Visual Tagnet Explorer script	Statistical analysis Average degree Graph density Modularity Component analysis Eigenvector centrality	Gephi 0.9.1
41 Pilar et al. (2021) Czech Republic	Instagram	English-speaking Instagram users posting using the hashtag #healthydiet	Consumption patterns and characteristics of foods associated with healthy meals	Images and captions	2,045,653 posts	Other – GitHub Instagram Scraper	Statistical analysis Frequency counts Eigenvector centrality Modularity	GitHub Gephi 0.9.2
42 Pilar et al. (2021) Czech Republic	Twitter	English-speaking Twitter users tweeting using the hashtag #healthy diet	Consumption patterns and characteristics of foods associated with healthy meals	Tweets	666,178 tweets	Twitter API	Statistical analysis Frequency counts Eigenvector centrality Modularity	Gephi 0.9.2 ForceAtlas algorithm
43 Platania et al. (2018) Italy	Twitter	Twitter users tweeting about Tuscan and/or Sicilian food	Food consumption patterns in Tuscany and Sicily	Tweets	456 tweets for Sicily and 442 tweets for Tuscany	Manual data scraping (downloads)	Manual thematic analysis Content analysis Inductive coding Statistical analysis Frequency counts Density Centralisation	UCINET NetDraw
44 Puerta, et al. (2020) Spain	Twitter	Spanish twitter users tweeting about gluten-free foods, recipes or products	Attitudes/perceptions of gluten free products and foods	Tweets	16,386 tweets	Twitter API (using rtweet package of R software)	Manual thematic analysis Natural language processing Co-occurrence networks	VOSviewer software, version 1.6.7 N-gram analyser tool NVivo software, version 12tm and ngram packages of R software



TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
45 Regan et al. (2014) Ireland	Other – 2 well known British news media websites (not specified)	Online users commenting on two well-known British news media websites	Attitudes/perceptions around the health risks of meat consumption	Comments	959 comments	Manual data scraping (downloads)	Manual inductive thematic analysis 'Constant Comparison' method	NVivo 8 & 9 (to organise data)
46 Rintyarna et al. (2015) Indonesia	Twitter	Indonesian Twitter users commenting about organic food consumption	Attitudes/perceptions of organic food during the COVID-19 pandemic	Tweets – geotagged	Not specified	Twitter API (using the OAuth package of R language software)	Natural language processing (sentiment analysis, polarity analysis) Hashtag clustering Network spatialisation Wordcloud Tokenisation Statistical analysis Frequency counts	VADER Force Atlas Gephi OAuth package of R Python
47 Ross et al. (2020) Australia	Twitter	American Twitter users using the hashtag #secondcivilwar-letters	Attitudes/perceptions and use of food references as indexical links to particular identities	Tweets	252 tweets	Twitter API	Manual thematic analysis Content analysis Inductive coding	
48 Said et al. (2014) The Netherlands	Other – <a href="http://Allrecipes.com">Allrecipes.com</a>	English-speaking, American <a href="http://Allrecipes.com">Allrecipes.com</a> users ( $n = 170,000$ )	Food consumption patterns and associations between food environments and obesity	Other – recipe likes, ratings & content	54,000 recipes and 17 M recipe ratings	Other – Scraping tools GitHub Recipe Crawler	Statistical analysis Frequency counts Significance tests	GitHub Recipe Crawler
49 Saura et al. (2020) Spain	Twitter	Twitter users tweeting using the hashtags #Diet and #FoodDiet	Attitudes/perceptions of food	Tweets	10,951 tweets	Twitter API	Natural language processing (sentiment analysis) LDV SVM Gibbs sampling Statistical analysis Krippendorff's Alpha Frequency counts	Python 3.7.0 NVivo software

(Continues)

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
50 Sharma et al. (2015) United States	Instagram	English-speaking Instagram users posting about food	The caloric content and subsequent attitudes/perceptions of meals	Images and captions	1,815,752 posts	Manual data scraping (downloads) & Instagram API	Statistical analysis Probability frequency distributions Distribution Welch t-tests	
51 Silva et al. (2014) Brazil	Twitter, Foursquare	Users who share their Foursquare check-in links through tweets about where they eat and drink.	Food and drink preferences and temporal food behaviours (time, day of the week)	Check-ins	4.7 M tweets with Foursquare check in links	Twitter API	Natural language processing PCA Statistical analysis Pearson's correlation coefficient Shannon's entropy Frequency counts	k-means algorithm (a clustering technique)
52 Simunaniami et al. (2011) Sweden	Other – 50 Swedish weblogs	Swedish bloggers writing about fruit and vegetables	Attitudes/perceptions of fruit and vegetable consumption	Other – blog posts	205 weblog entries from 50 weblogs	Other – top Google search results	Manual thematic analysis Open coding	NVivo 8
53 Sun et al. (2018) China	Twitter	American Twitter users	Food consumption patterns and associations with state obesity rates	Tweets – geotagged	Not specified	Twitter API	Statistical analysis Multi-linear regression model Correlation (between study factors)	
54 Supphanasup et al. (2021) Australia	Facebook	Members within Facebook support groups that are parent-run, communicated in Thai and about child feeding practices	Thai parents' attitudes/perceptions of child eating practices	Comments	200 posts and 1964 responding comments	Manual data scraping	Manual thematic analysis Thematic content analysis with inductive coding Statistical analysis ANOVA Frequency counts Significance tests	Atlas.ti program SPSS
55 Teng et al. (2020) Malaysia	YouTube	YouTube users commenting on Malaysian 'healthy eating' videos	Attitudes/perceptions of healthy food	Comments	4654 comments	Manual data scraping	Natural language processing (sentiment analysis) Text parsing Tokenisation	Text Miner 94 Singular Valve Decomposition algorithm (for semantic indexing)

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
56 Tosun et al. (2018) Turkey	Other – Turkish web forums – <a href="http://forum.donanimhaber.com">forum.donanimhaber.com</a> , <a href="http://kizlarsoruyor.com">kizlarsoruyor.com</a> and <a href="http://eksisozluk.com">eksisozluk.com</a>	Users of 3 Turkish web forums posting about anti-meat consumption	Attitudes/perceptions around the avoidance of meat consumption	Comments	378 comments	Manual data scraping using keyword ‘meat’	Manual thematic analysis Deductive coding into themes Statistical analysis Data frequency and distribution	SPSS
57 Trattner et al. (2017) Austria	Other – <a href="http://Allrecipes.com">Allrecipes.com</a>	Users of <a href="http://Allrecipes.com">Allrecipes.com</a> who could be objectively mapped to a state and a county in the United States	Food consumption patterns, popularity of high fat, high sugar recipes online and associations with state and county-level obesity	Other – book-marks (geo-tagged)	58,263 recipes	Other – Scraping tools, Google Places Web API	Statistical analysis Pearson correlation coefficient Multi-level regression Unconditional means model Unconditional growth model	Google Places Web API lmer package
58 Vargas et al. (2015) South Korea	Twitter	Mexican and Korean Twitter users tweeting about organic food products	Attitudes/perceptions of organic food	Tweets – geotagged	1828 tweets from Mexican users + 4943 tweets from Korean users	Twitter API (using NodeXL software)	Natural language processing (semantic analysis) Word co-occurrences Word matrices with network visualisation (centrality, geodesic distance) Statistical analysis Clustering coefficient	Nodexl Webometric Analyst Frqlist Fulltext Krkwic NetDraw (using Fruchterman–Reingold algorithm and Harel–Koren Fast Multiscale algorithm)
59 Vargas et al. (2020) Japan	YouTube	YouTube users	Attitudes/perceptions of organic food	Videos and comments	923 videos	YouTube API with some manual extraction	Natural language processing (semantic and polarity analysis) Statistical analysis Spearman correlations	Gephi TI Sentistrength

(Continues)

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
59 Vidal et al. (2015) Uruguay	Twitter	Twitter users (English and non-English) microblogging about different meal times.	Food behaviours around meal times (breakfast, lunch, dinner & snacks)	Tweets	48,746 tweets	Twitter API (using twitterR package of R software)	Manual thematic analysis Inductive coding into themes & subthemes Statistical analysis Frequency counts $\chi^2$ test	
60 Vidal et al. (2016) Uruguay	Twitter	Twitter users using emoticons or emojis when writing about food.	Attitudes/perceptions of food, conveyed through emoji use	Tweets	12,260 tweets	Twitter API (using twitterR package of R software)	Manual thematic analysis Categorisation of emotional valence (+ive, neutral, -ive) Statistical analysis Frequency counts $\chi^2$ test	
61 Vydiswaran et al. (2018) United States	Twitter	Twitter users in Metropolitan Detroit tweeting about food	Food consumption patterns associated with neighbourhood health outcomes and attitudes/perceptions of healthy and unhealthy foods	Tweets – geotagged	822,604 tweets	Twitter API (using Twitter Gardenhose stream)	Natural language processing (sentiment analysis) SVM Naive Bayes Statistical analysis Frequency counts Random Forest Logistic regression Non-parametric Kruskal–Wallis $H$ test	Humanizor tool Hybrid-SVM classifier
62 Vydiswaran et al. (2020) United States	Twitter	Twitter users in Metropolitan Detroit tweeting about food	Food consumption patterns and associations between neighbourhood food environments, socio-economic status and	Tweets – geotagged	822,604 tweets	Twitter API (using Twitter Gardenhose stream)	Manual thematic analysis Qualitative content analysis with inductive coding KDE SVM Statistical analysis Bivariate and multivariate regressions	Humanizor tool Hybrid-Support Vector Machine classifier

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
63 Walsh, et al. (2020) Australia	Instagram	Instagram users using hashtags related to 'clean eating'	Food attitudes/perceptions of clean eating	Images and captions	144 posts	Instagram API	Manual thematic analysis Visual theme categorisation	Instagram API
64 Wang et al. (2018) Japan	Twitter	Twitter users living in London, Rome, Paris, Barcelona, Berlin, Lisbon, Amsterdam who speak Italian, French, Spanish, German, Polish, Portuguese or Dutch.	Food consumption patterns and venue preference between major cities	Tweets – geotagged	26 M tweets	Twitter API & Foursquare API	Statistical analysis Pearson correlation coefficient	Map-based web application developed using PHP, JavaScript, and HTML
65 Wang et al. (2020) United States	Twitter	Twitter users self-diagnosed with a mental disorder tweeting about supplement intake	Supplement consumption patterns in mental disorder patients	Tweets	993 tweets	Twitter API	Natural language processing (sentiment analysis) LIWC SVM Convolutional neural network (CNN) Multi-layer perceptron (MLP) Random Forest Statistical analysis Cosine similarity Frequency counts Two-sample independent t-test	Word2Vec FastText vectors GloVe vectors
66 Widener et al. (2014) United States	Twitter	American Twitter users	Food consumption patterns including prevalence of unhealthy food discussions in	Tweets – geotagged	148,533 tweets	Twitter API	Natural language processing (sentiment analysis) Adjective and adverb extraction Sentiment classification KDE	Alchemy API

(Continues)



TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
			disadvantaged areas				Statistical analysis KDE Logistic regression models Coefficients (as adjusted odds ratios)	
67 Widmar et al. (2020) United States	Twitter, Reddit, Instagram, TripAdvisor, blogs, online forums ( <a href="https://backyardchickens.com">backyardchickens.com</a> )	English-speaking social media users from the United States	Attitudes/perceptions of egg varieties	Tweets, Instagram posts (images and captions), Reddit posts, online blog & forum posts	14M mentions across all social platforms	Other – Netbase social analytics platform	Natural language processing (sentiment analysis) Net sentiment Statistical analysis Frequency count	Netbase's Natural Language Processing engine
68 Woodruff et al. (2021) Canada	Facebook, Twitter	Facebook and Twitter users commenting about Canada Food Guide	Attitudes/perceptions of Canada's 2019 Food Guide	Facebook comments, Tweets	2574 Facebook comments and 1458 tweets	Other – Meltwater data extraction tool	Natural language processing (semantic & thematic analysis) Concept map with heat mapping Manual thematic analysis Axial coding Statistical analysis Frequency count Intraclass correlations (ICC)	Leximancer IBM SPSS Statistics, version 25
69 Zhang et al. (2019a) China	Other – <a href="https://allrecipes.com">Allrecipes.com</a> (American recipe platform), <a href="https://xiachufang.com">Xiachufang.com</a> (Chinese recipe platform), Kochbar.de (German recipe platform)	Not specified	Attitudes/perceptions of recipes based solely on its visual properties	Other – recipes from <a href="https://allrecipes.com">allrecipes.com</a> , kochbar.de and <a href="https://xiachufang.com">xiachufang.com</a>	72,899 recipes	Other – Scraping tools (unspecified)	Image analysis Deep Neural Network image embeddings (DNN) Explicit visual features (EVF) Naive Bayes Random forest Statistical analysis Logistic regression	ImageNet dataset within VGG-16 DNN (a deep neural network developed to classify images)

TABLE 1 (Continued)

First author	Social media platform(s)	Population(s)	Nutrition topic(s) studied	User response measured	Size of data set	Method of data collection	Method of data analysis	Programs/algorithms/models used
70 Zhang et al. (2019b) China	Other – (1) Sina Weibo (2) MeiShijie	Users/microbloggers of Sina Weibo posting about food	Food consumption patterns in different Chinese regions	Other – Sina Weibo posts	(1) 5156 types of dishes retrieved from MeiShijie (2) 3,209,990 microblogs mentioning one of the 5156 dish types retrieved from Sina Weibo	Sina streaming API	Natural language processing Word segmentation Cosine distances Statistical analysis Frequency count	Jieba (a Chinese word segmentation tool)
71 Zhou et al. (2017) China	Other – Sina Weibo – <a href="http://weibo.com">weibo.com</a> (a Chinese microblogging website)	3,975,800 users/microbloggers of Sina Weibo posting about food	Food consumption patterns and dietary preferences in China	Other – Sina Weibo posts	8,748,195 microblogs about 25,675 types of dishes/meals	Sina streaming API	Natural language processing (sentiment analysis) LDA Cosine distances Statistical analysis Pearson correlation coefficient	A skip-gram model in Word2Vec

Abbreviations: API, application program interface; LDA, latent Dirichlet allocation; PCA, principal component analysis; SVM, Support Vector Machine.









( $n = 15$ ) were restricted to a specific population by using highly targeted platforms (e.g., Swedish news boards) or topics and 15% ( $n = 11$ ) were restricted to English-only posts.

## Nutrition topics studied

The most common nutrition research domains studied were food consumption patterns (the primary focus of 42%,  $n = 30$ ) and food attitudes and perceptions (41%,  $n = 29$ ), whereas only 1% ( $n = 1$ ) focussed on food behaviours. The remaining 15% ( $n = 11$ ) of studies investigated a combination of these research domains. Forty two percent of all included studies ( $n = 30$ ) identified a specific food, food type, diet, behaviour or attitude/perception in the research question (e.g., the consumption of fruit and vegetables, or the perception of Halal food), whereas 58% of studies ( $n = 41$ ) did not limit the research to a specific sub-topic.

## Datasets

Communication between users on social media can occur through various modes. This includes through posts, 'likes', comments, geolocations and 'shares'. Within the included studies, user-generated posts (both written and photographic) were most commonly explored by researchers, occurring in 72% ( $n = 51$ ) of studies. Comments were independently explored in 13% ( $n = 9$ ) of studies, geolocations in 4% ( $n = 3$ ), shares in 3% ( $n = 2$ ), and likes and video content each in 1% ( $n = 1$ ). Eight studies (11%) did not fall into any of these categories, instead exploring user content such as restaurant reviews, recipes or 'bookmarks'.

Within 25% ( $n = 18$ ) of studies, a dataset of  $\geq 1$  million user responses was used. In the remaining studies, 20% ( $n = 14$ ) used datasets between 50,000 and 999,999 user responses, 25% ( $n = 18$ ) used datasets between 1000 and 49,999 user responses and 25% ( $n = 18$ ) used datasets between 0 and 999 user responses. In 4% ( $n = 3$ ) of studies, the number of user responses included in the dataset was not specified.

## Methods of data collection

Most studies (55%,  $n = 39$ ) used an API to collect the data. Of these 39 studies, 31 accessed the API directly or did not specify how it was accessed and eight accessed the API using a third-party program or website. In the remaining studies, 24% ( $n = 17$ ) collected data using manual scraping techniques, 17% ( $n = 12$ ) used other methods including analytics websites and other programs to obtain data and 4% ( $n = 3$ ) used a combination of these data collection methods.

## Methods of data analysis

Data analysis was most often conducted using a combination of analytical methods however 13% of studies ( $n = 9$ ) relied solely on content analysis, 11% ( $n = 8$ ) used natural language processing methods alone, 4% ( $n = 3$ ) used deductive thematic analysis alone and 10% ( $n = 7$ ) used statistical analysis alone. In total, 62% ( $n = 44$ ) used a combination of the aforementioned methods. Of these 43 studies, Natural Language Processing (NLP) with statistical analysis was the most common combination (38% of studies,  $n = 27$ ), followed by content analysis with statistical analysis (13% of studies,  $n = 9$ ), and studies using other combinations such as deep learning with statistical analysis ( $n = 3$ ) content and deductive thematic analysis ( $n = 2$ ), content analysis with NLP ( $n = 1$ ), or another combination of methods ( $n = 1$ ).

## Year of publication and study location

All studies were published within 2011–2021 with no studies conducted during 2003–2010. Although the inclusion criteria considered studies from the past 19 years (2003–2021), 66% ( $n = 47$ ) had a publication date within the most recent 5-year period (2017–2021). The most common years for publication were 2018 and 2020, each comprising 17% ( $n = 12$ ) of included studies. Studies originated from 25 unique countries. Grouped by region, North America and Europe had the highest research output consisting of 37% ( $n = 26$ ) and 28% ( $n = 20$ ) of studies respectively. In the remaining studies, 22% ( $n = 16$ ) originated from Asia, 6% ( $n = 4$ ) from both South America and Oceania and 1% ( $n = 1$ ) from Africa. No studies originated from Central America or the Caribbean. On a national level, 31% ( $n = 22$ ) of studies originated from the USA making it the country with the highest research output.

## Research discipline study originated from

Most studies originated from research disciplines in non-health related fields (42%,  $n = 30$ ) such as business, law and agriculture. Furthermore, 37% ( $n = 26$ ) of studies were conducted by IT or engineering researchers and only 18% ( $n = 13$ ) were from disciplines with a health basis (e.g., public health, psychology). Only 3% ( $n = 2$ ) of studies were conducted by researchers specifically in the nutrition field.

## Specificity of research topic

Only 4% of studies ( $n = 3$ ) targeted a specific food or beverage, 10% ( $n = 7$ ) targeted a specific behaviour and 37% ( $n = 26$ ) targeted a specific category of foods, diets or cuisines. The majority of studies (59%,  $n = 42$ ) specified a

geographical location range for their user population or targeted a specific social event and 15% ( $n = 11$ ) targeted a specific sub-population or demographic such as adolescents or bariatric patients. Approximately one in five studies (21%,  $n = 15$ ) aimed to map data to a specific health outcome such as national obesity rates and 13% ( $n = 9$ ) aimed to map data to the food environment. Only seven studies (10%) did not add any such additional specifications to the original research question.

## Method validation

Within this review, validation was defined as any steps taken to verify that a study's method is fit for purpose in answering the research question and producing credible results at the same time as also considering reliability of consistency of findings. When outlining their proposed method, approximately half of the identified studies (51%,  $n = 36$ ) did not specify whether any processes had been first implemented to validate their approach. Within the remaining 35 studies, 21% ( $n = 15$ ) manually validated their method for inter-researcher reliability (e.g., using a consensus coding or constant comparison approach) and 28% ( $n = 20$ ) employed statistical tests to do so (e.g., Cohen's kappa).

## DISCUSSION

This scoping review collated and categorised the use of social media by researchers as a means to understand population food consumption and behaviours and is the first to include small- and large-scale analyses of data sets. Commonalities were identified amongst the studies, including the popularity of the social media platform Twitter for data collection. Small-scale studies tended to use manual techniques including data scraping, manual coding and basic statistical analysis, whereas larger scale studies tended to use APIs and advanced analytic software, most commonly for natural language processing. Of interest was the high proportion of researchers from non-health related disciplines in the USA and Europe. Population food consumption patterns as well as population food perceptions were the most popular nutrition domains explored amongst studies, with many going on to map their findings to broader health outcomes, such as food choice in relation to obesity prevalence. The ability of social media analysis to adapt to this broad range of study aims highlights its versatility as a research method.

### Social media platforms

The most common social media platform used for data collection was Twitter. There are a number of reasons that

may have contributed to this finding. For example, Twitter requires all users to post publicly, thus maximising the amount of publicly available data. Additionally, the majority of Twitter's posts are text only and limited to 280 characters or less. This means user sentiments must be explained clearly and concisely, which consequently makes it easier for researchers to assign coding to posts and identify themes.<sup>32</sup> Furthermore, Twitter has a substantial commercial arm, 'Twitter Developer',<sup>33</sup> which offers a variety of API packages for purchase, as well as grants such as 'Academic Data Grants'<sup>34</sup> and 'Academic Research product tracks',<sup>35</sup> which offer eligible researchers greater access to Twitter data archives, at no financial cost.

Despite Facebook having the largest user base of any social media platform,<sup>36</sup> it was the focus of just three studies and incorporated in seven studies in total. Other research has suggested that a greater variety in the data (text, pictures, videos, geolocations, shares and multiple reaction options) makes it more complex to analyse and consequently there are less third-party analytics platforms equipped to do so.<sup>37</sup>

### Nutrition domains studied

The most common nutrition research domains studied were food consumption patterns and food attitudes and perceptions, whereas only one study focussed solely on food behaviours. This may be related to the paucity of social media data available on food behaviours specifically. Research by Barre *et al.*<sup>38</sup> found that the main themes identified in food related posts on social media were to share exceptional or appealing food, food in the social context, eating out, emotions about food and food advice.<sup>38</sup> This type of data restricts the ability to draw conclusions about food consumption in other contexts such as the home and workplace. Other behavioural factors such as number of eating occasions, meal timing and time spent eating meals and snacks also important to understanding food consumption behaviours were not captured. Less than half of the studies identified a specific food-related topic in the research question (e.g., the consumption of dairy).

### Growth in social media analysis for health research

Social media analysis for nutrition research appears to still be in its infancy and therefore largely exploratory, favouring a more open-ended style of investigative approach. Between the years 2003 and 2010, despite the existence and rapid growth of social media throughout this time, no nutrition-related studies were published.<sup>3</sup> It is noted however that small-scale studies investigating other health behaviours during this time period can be found. For example, a 2009 study by Moreno *et al.*<sup>39</sup> used manual content analysis of 500 public Myspace

accounts to investigate the display of health risk behaviours such as sexual behaviour, substance use and violence in 18 year olds. Nevertheless two-thirds of studies captured in this literature review had a publication date within the most recent 5-year period (2017–2021), likely as a result of the exponential growth and popularisation of sophisticated data analytics from 2010 onwards.<sup>40</sup>

## Research methodologies and researcher backgrounds

Reviewing the methods of data analysis within our included papers reveals studies stemming from the health and nutrition fields focused largely on the manual thematic analysis of smaller sets of data. In comparison, the datasets of studies conducted by software engineering and information technology researchers often fell in the millions and focused on utilising automated processes such as computer-based, language processing software. Manual thematic analysis by researchers comes with the benefit of being able to identify nuances in language such as irony or satire, which has potential to be incorrectly coded by computer software.<sup>41</sup> In comparison, the benefits of utilising data software and algorithms include a reduced burden on researchers, the capability of processing large datasets and shorter timeframes.<sup>41</sup> Therefore, future collaboration of these methods and research disciplines positions itself as a harmonious option, particularly due to the anticipated growth within this area. It is recommended that nutrition researchers will benefit from partnering with information technology and software engineers to fully realise the research potential of social media and how to effectively employ this as a research method. In addition, it was noted that a minority of studies attempted to determine the validity or reliability of their methods and nutrition researchers could inform this process as it is routine in dietary assessment and healthcare generally.

Most studies were either conducted in the USA or utilised data collected from social media in the USA including that from researchers in Qatar, Germany, Australia, the Netherlands, China and Austria. Because food consumption patterns are heavily influenced by culture and food environments the research on dietary consumption patterns, attitudes and behaviours are largely specific to the USA and therefore broader applications of such findings may be limited. Researchers should be encouraged to consider social media from a broader global audience when possible.

## Ethical considerations

Facebook has been the focus of recent controversy as a result of violations of user privacy, which led to tighter

privacy restrictions on user data.<sup>42</sup> Although the ethical considerations of each study were not explored in this review, it is noted that some of the included studies such as the investigation into food consumption and behaviours following bariatric surgery by Koball *et al.*<sup>43</sup> accessed private groups on Facebook to collect data. Although the study concerned had Institutional Review Board approval, it serves to illustrate what may be a complex ethical issue. The ethical nature of this form of data collection is not well defined<sup>44</sup> and, notably, many users may agree to ‘terms and conditions’ detailing the use or sale of their data without realising, further complicating the issue for lawmakers and governing bodies.<sup>18</sup> Additionally, although users may knowingly consent to their data being used anonymously, this anonymous data may then be hacked or stolen and reidentified by triangulating the anonymous data with publicly available data to identify the original user without their consent.<sup>18</sup> Concerns have also been raised regarding the improper use of social media analysis to profile and target minority groups with misleading information.<sup>18</sup>

These ethical concerns emphasise the need for further enquiry and discussion at an international level. It is suggested the development of ethical guidelines and frameworks is prioritised to inform future studies.

## Applicability to nutrition practice, policy and research

Social media analysis is a nascent method for assessing population dietary patterns and behaviours, with potential for rapid future growth. The versatility of this method means that it is applicable to nutrition practice and policy in a variety of settings. More specifically, clinician and public health nutritionists/dietitians could benefit from the insights gained from social media analysis around food attitudes and trends. For example, two studies published by Pilar *et al.*<sup>40</sup> in 2018 (see Supporting information, Appendix 2) and Pilar *et al.*<sup>41</sup> in 2021 (see Supporting information, Appendix 2) reveal growing population preference for foods that are organic and sustainable as well as increased popularity in vegetarian diets. A study by Puerta *et al.*<sup>44</sup> in 2020 (see Supporting Information, Appendix 2) also notes positive discussion on social media regarding the gluten free diet, even by individuals without coeliac disease or non-coeliac gluten sensitivity. Keeping informed of both positive and negative trends in dietary consumption and attitudes to certain foods is important for those working in dietary guidance.

There have been other scoping reviews undertaken to investigate studies using social media analysis in the field of health research more broadly<sup>45–47</sup> and one focusing on 34 nutrition studies was identified.<sup>25</sup> Of the 79 studies in the current review, only 11 overlap, which may be attributed to differences in search strategies. Twenty-one of the studies included here were published after the date of the other review's<sup>25</sup> search of databases (2020–2021).

Nevertheless, commonalities were observed, including the finding that Twitter data was most commonly used, few were from the nutrition discipline and most studies were from the USA.

## Limitations

A strength of this review is that it followed robust guidelines and frameworks for scoping reviews,<sup>26–28</sup> as well as a rigorous exclusion criteria. Nevertheless, there are a number of limitations to this review. Most studies did not use validated methods, limiting the scientific veracity and weakening the overall quality of the studies. Studies were limited to English-only, resulting in the likely exclusion of studies published in countries such as China and India where social media analysis may be commonly used.<sup>48,49</sup>

When charting the study location and research discipline, this information was extracted from the author's credentials, using a Google search if required and therefore this information may not be guaranteed. Finally, because this review followed the JBI guidelines for scoping reviews, a risk of bias analysis was not performed.

## CONCLUSIONS

Social media analysis for the purpose of investigating food consumption patterns and behaviours is an emerging field with a wide variety of applications; however, current research predominantly originates from disciplines outside of health and, more so, outside of nutrition. As such, future research in the field of nutrition should be encouraged and supported by the creation of methodological and ethical frameworks, as well as partnerships between experts in nutrition and information technology. Importantly, method validation was lacking in most studies and therefore such methodological and ethical frameworks must address the need for method validation, as well as provide appropriate guidance for doing so. The popularity of Twitter for data collection suggests that costs, time and ease are all important factors considered by researchers but exploration of social media platforms other than Twitter should be encouraged. Moving beyond traditional methods of dietary data collection may prove social media as a useful adjunct to inform recommended dietary practices and food policies.

## AUTHOR CONTRIBUTIONS

*Conceptualisation:* Jasmine Titova, Georgia Cottis and Margaret Allman-Farinelli. *Methodology:* Jasmine Titova, Georgia Cottis and Margaret Allman-Farinelli. *Formal analysis:* Jasmine Titova, Georgia Cottis and Margaret Allman-Farinelli. *Writing—original draft*

*preparation:* Jasmine Titova and Georgia Cottis. *Writing—review and editing:* Margaret Allman-Farinelli. *Supervision:* Margaret Allman-Farinelli. All authors approved the final version of the manuscript submitted for publication.

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## CONFLICTS OF INTEREST

Margaret Allman-Farinelli reports grants from National Health and Medical Research Council, Australian Research Council, NSW Health and Cancer Council NSW, outside the submitted work. Jasmine Titova and Georgia Cottis declare that they have no conflicts of interest.

## ETHICAL STATEMENT

Ethical approval was not obtained for this review because it did not involve human subjects or animals directly.

## TRANSPARENCY DECLARATION

The lead author declares that this manuscript is an accurate and transparent record of the study undertaken. Any discrepancies have been detailed and no pertinent study details or findings have been omitted.

## PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1111/jhn.13077>

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Do sauces, condiments and seasonings contribute important amounts of nutrients to Australian dietary intakes?

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## Abstract

**Background:** Dietary assessment commonly focuses on particular foods/food groups as indicators of overall dietary intake. Accompaniments such as sauces, condiments and seasonings (SCS) using the most recent Australian National Nutrition and Physical Activity Survey (NNPAS), as well as the contribution to total energy and selected nutrient intakes.

**Methods:** NNPAS dietary data were collected by one 24-h recall for 12,153 individuals aged  $\geq 2$  years (53% female, 29% aged 31–50 years). SCS (i.e., any food items not normally consumed as a food itself, consumed as an addition to a dish after cooking/preparation to enhance flavour) were identified/coded within the dietary data and reported in terms of how they were consumed, primary composition, and contribution to total daily energy and selected macro- and micronutrient intakes.

**Results:** Most participants (85.1%) reported consuming at least one SCS on the day of the recall (median [interquartile range], 2 [1–4]). SCS were predominantly consumed within main meals (breakfast, lunch, dinner) (73.9%), and were predominantly sugar/sugar products (e.g., white sugar) (35.0%), or fats and oils (e.g., butter) (25.9%). SCS contributed a median (interquartile range) of 3.8% (1.1–7.9) of total energy, 5.3% (0.0–15.5) of fat, 2.3% (0.1–6.6) of carbohydrate and 0.2% (0.01–1.2) of protein intake. SCS made the largest contribution towards vitamin E (females median 3.6%; males median 3.4%) and sodium intakes (females median 3.0%; males median 2.9%).

**Conclusions:** Although SCS contribute a small proportion of total energy and nutrient intakes in the Australian population, the contribution is more substantial for some nutrients and population groups.

## KEYWORDS

Australian Health Survey, condiments, dietary intake, sauces, seasonings

## Key points

- Sauces, condiments and seasonings are small contributors to Australians' energy and nutrient intakes.
- Sauces, condiments and seasonings may have positive and negative contribution.
- Contributions vary by age and gender, and are more substantial for older adults.

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## INTRODUCTION

Dietary intakes among the Australian population are generally aligned with a Western dietary pattern, characterised by lower than recommended intakes of nutrient dense foods, such as vegetables and wholegrains, and higher than recommended intakes of energy-dense, nutrient-poor (EDNP) foods, such as ultra-processed food products high in saturated fat, sodium and added sugars.<sup>1,2</sup> The average Australian adult consumes less than half of the recommended five or six daily serves of vegetables,<sup>2</sup> whereas 35% of total daily energy intake is derived from EDNP foods<sup>1</sup> and 12% is from saturated fat,<sup>3</sup> and the average daily salt intake is 9.6 g or twice the recommendations.<sup>4</sup>

Dietary assessment usually focuses on intakes of particular foods or food groups as indicators of overall dietary intake or diet quality, especially at the population level.<sup>5</sup> For example, capturing usual daily intakes of fruit, vegetables or wholegrains consumed and then comparing this with either population norms or recommendations in national dietary guidelines. However, these items are commonly consumed with accompaniments such as sauces, condiments and/or seasonings (SCS),<sup>6</sup> which potentially contribute important amounts of energy and nutrients.

SCS are defined as substances that are consumed with, or added to, a food item or meal at the time of eating for the purpose of enhancing flavour.<sup>7</sup> Adding SCS to meals is commonplace in dietary patterns in high income countries,<sup>1,6,8</sup> including Australia, New Zealand, the UK and the USA, and particularly among some population groups such as older adults.<sup>6,8</sup> For example, analysis of the 2011–2012 Australian National Nutrition Survey data identified that approximately 1.4% of daily energy in Australians aged 2 years and over came from savoury sauces, dips and condiments.<sup>1</sup> This included items such as gravy and tomato sauce and, although contributing to a small proportion of total energy intakes, limited data have explored the contribution to nutrient intakes or by category of accompaniment. SCS includes both EDNP items and nutrient-dense options, and therefore includes items that potentially make an important contribution to intakes of essential nutrients,<sup>9</sup> as well as intakes of some nutrients linked to chronic disease risk, such as saturated fat and sodium.<sup>10</sup> However, to date, intakes of SCS have not been comprehensively analysed in detail either internationally or in Australia in terms of their contributions to essential nutrients. Therefore, there is an evidence gap regarding the contribution of SCS to overall dietary intakes, including intakes of specific vitamins and minerals. Such findings have the potential to inform policy and practice related to reformulation targets, potential food fortification programs<sup>11</sup> and population recommendations regarding intakes of SCS.

The present study therefore describes daily intakes of SCS in Australians aged 2 years and over, and determines

their contribution to total energy intake and selected nutrient intakes using data from the most recent National Nutrition and Physical Activity Survey (NNPAS).

## METHODS

### Study design

This study is a secondary analysis of dietary intake data collected as part of the 2011–2012 NNPAS, a component of the Australian Health Survey (AHS) 2011–2013 conducted by the Australian Bureau of Statistics (ABS). The AHS collected data from 32,000 people across Australia, with this analysis including the 12,153 people who completed the NNPAS component. Further details on the methods of the AHS are available via the ABS website.<sup>12</sup> The dietary intake data were collected by trained interviewers and using a 24-h recall method, where participants are asked to recall all food and drinks consumed within the previous 24-h period. All 12,153 people completed one 24-h recall, and a subset of this sample (64%) also completed a second 24-h recall. Only the day one 24-h recalls were used in the present study because these were available for the entire study sample, similar to previous analyses of NNPAS data.<sup>13,14</sup> For participants aged 15 years or younger, interviews were conducted with a parent or guardian proxy and/or the child. An automated multiple-pass method and food model booklets were used in interviews to improve the accuracy of data collection and assist with recall and quantity estimations. The season and day of the week of the 24-h recall was also documented. Nutrient intake data were generated from collected dietary data with reference to the Australian Food and Nutrient (AUSNUT) 2011–2013 database.<sup>15</sup> Further details on the NNPAS methodology are available via the ABS website user guide.<sup>12</sup> The NNPAS was granted ethical approval from the Ethics Committee of the Australian Government Department of Health and Ageing. Ethical approval for this secondary analysis was granted by the University of Newcastle Human Research Ethics Committee. The conduct and reporting of this work complies with STROBE-nut guidelines.<sup>16</sup> This secondary analysis was not pre-registered and therefore results should be considered as exploratory.

### SCS intakes

SCS were defined as any food items not normally consumed as a food itself that were consumed as an addition to a dish after cooking/preparation to enhance flavour.<sup>7,17</sup> A defined list of food items was created, excluding food items typically consumed as a food by themselves, or added for other reasons including nutritional value, or as an essential ingredient. Alcoholic beverages were excluded.

The defined list of food items was determined in a three step process:

1. Reviewing the AUSNUT 2011–2013 food composition database, food details file
2. Reviewing the 24-h recall data at the level of the individual food items consumed
3. Review and revision of the generated list from steps one and two by the research team until consensus was reached on inclusions

Steps one and two were conducted by one dietitian researcher (MW), including a manual review of a 5% subsample of the 212,235 reported food items from the 12,153 24-h recalls in the full dataset ( $n = 10,612$  food item observations reviewed). The data were sorted by person and eating occasion and the first 5% reviewed. This approach was used so that food items could be considered in the context of how they were consumed, rather than a random approach.

The food item being consumed as an addition to a dish was determined by cross-checking the food combination type code with the eating occasion and time of eating for all food items within the respective dish and eating occasion. For example, in a meal consisting of toast with butter and hazelnut spread where all three food items had the same food combination type code (bread/baked products with additions), eating occasion (breakfast) and time of eating (7:30 AM), the butter and hazelnut spread are considered as being consumed as an addition to the toast. However, if the hazelnut spread instead had a food combination type code of 'not applicable' and a time of eating of 7:05 AM, it would have been considered as a separate food item and only the butter as an addition to the toast.

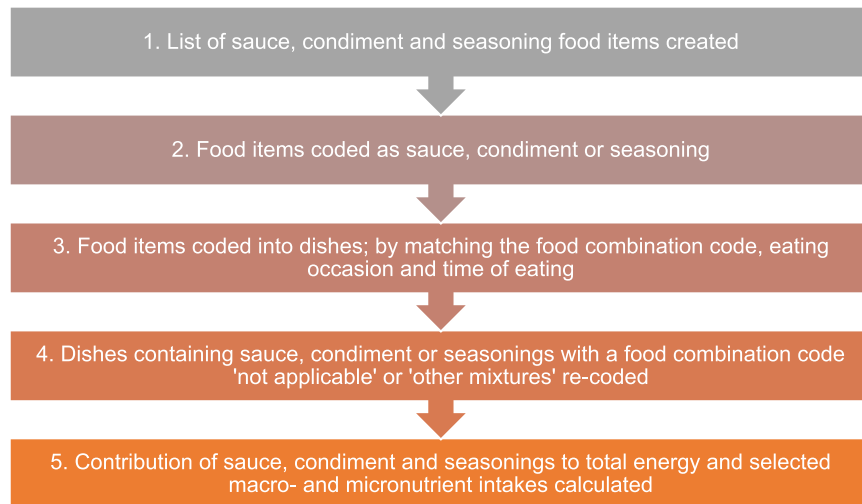
The food combination type is an existing variable within the NNPAS dataset, where food items have been coded into one of 14 food combination types depending on what they are consumed with. The 14 food combination types include beverages with additions; cereal with additions; bread/baked products with additions; salad; sandwiches/wraps/rolls with fillings; soup; frozen meal; ice cream/frozen yoghurt with additions; vegetables with additions; fruit with additions; tortilla products; meat, poultry and fish; chips; other mixtures; and not applicable. Further detail on the food combination type variable is available via the ABS website.<sup>12</sup>

Dishes were defined as being made up of any number of food items with the same food combination type code that were consumed at the same time within the same eating occasion. This is not an existing variable in the NNPAS dataset and was created for the purposes of this analysis. For example, a breakfast eating occasion where coffee with milk and sugar (food combination type = beverage with additions) and toast with butter and

jam (food combination type = bread/baked products with additions) were consumed consists of two 'dishes'. This definition was used to separate out the specific food item/s that SCS were added to and to enable the calculation of the weight, energy and nutrient contribution of the SCS. Using the above example, this separated 'dishes' approach allowed for the contribution of the sugar added to coffee and the butter and jam added to the toast to be calculated.

Dishes that included SCS and that were originally coded with a food combination type of 'other mixtures' or 'not applicable' were re-coded so that we could describe what the SCS were eaten with in these dishes. These were re-coded to the most applicable of the other existing food combination categories outlined above; for example, crepes with maple syrup originally coded as 'not applicable' was re-coded to 'bread/baked products with additions'. Some of these dishes did not fit into the other existing food combination categories and, for this reason, the following changes were made to two of the categories to include a broader combination of food items. Ice cream/frozen yoghurt with additions became ice cream, and yoghurt or custard with additions and, for example, custard with cinnamon originally coded as 'other mixtures' were re-coded to 'ice cream, yoghurt or custard with additions'. Meat, poultry and fish became meat, poultry, fish and alternatives and, for example, meat alternative (i.e., fake meat) with pepper originally coded as 'other mixtures' was re-coded to 'meat, poultry, fish and alternatives'. In addition, five new food combination categories were created to account for dishes where none of the above food combination categories applied. The five newly created food combination categories and example dishes within these included; pasta dish with additions (e.g., ravioli with cheese), rice or other grain-based dish with additions (e.g., sushi with soy sauce), meat and/or vegetable based hot dish with additions (e.g., casserole with pepper and Worcestershire sauce), egg based dish with additions (e.g., scrambled eggs with tomato sauce) and savoury pastry or fried food with additions (e.g., meat pie with tomato sauce). The re-coding was conducted by two dietitian researchers (MW and EC), in consultation with the research team to ensure consensus in decision-making. Figure 1 summarises the overall coding process.

Food items in the results are described according to whether they were categorised as a sauce, condiment or seasoning, how they were consumed (food combination type) and the primary composition of the food item according to their major, sub-major and minor food group defined in the AUSNUT 2011–2013 database (for further detail and examples, see Supporting information, Tables S1–S3). All categorisations were consistent with NNPAS and AUSNUT 2011–2013 methodology and definitions.



**FIGURE 1** Overview of data coding process to calculate contributions of sauces, condiments and seasonings to nutrient intakes using the National Nutrition and Physical Activity Survey (NNPAS)

## Demographic characteristics

Demographic characteristics drawn from the NNPAS survey for use in this secondary analysis included age, sex, country of birth, Socio-Economic Indexes For Areas (SEIFA) as an indicator of socio-economic status, and Australian Statistical Geography Standard-Remoteness Area (ASGS-RA) as an indicator of geographical location. Age was reported as an age group to be consistent with age group classifications used by the Australian Nutrient Reference Values (NRV) (2–3 years; 4–8 years; 9–13 years; 14–18 years; 19–30 years; 31–50 years; 51–70 years; > 70 years).<sup>18</sup>

## Statistical analysis

Stata, version 14.2 (StataCorp) was used for analyses. Sample demographic characteristics are presented as numbers and percentages. Most dietary intake data are presented as the median and interquartile range (IQR) given the skewness of the data, or the mean  $\pm$  SD for normally distributed data.

## RESULTS

### Overview of the study sample

The sample included 12,153 individuals; 53% female, 75% born in Australia, with the largest proportion aged between 31 and 50 years (29%) (Table 1).

### Overall description of SCS intakes

The majority of the sample reported having consumed one or more SCS on the day of the recall (85.1%), whereas 14.9% did not consume any. Respondents

reported a mean  $\pm$  SD of  $5.4 \pm 1.2$  eating occasions, a mean  $\pm$  SD of  $7.6 \pm 2.2$  dishes and a median (IQR) of 2 (1–4) SCS consumed on the day of the recall. SCS contributed a median (IQR) of 5.5% (1.9%–12.7%) of the gram weight per dish or a median of 157.8 g (79.0–270.8 g) per dish. SCS were predominantly consumed (73.9%) within main meals (i.e., breakfast, lunch, dinner) (Figure 2), followed by beverages (10.3%) and snacks (4.9%). SCS were most commonly added to bread/baked products (28.6%), followed by beverages (27.1%) and sandwiches/rolls/wraps (15.7%) (Figure 3). SCS were predominantly sugar and sugar products (e.g., white sugar, honey) (35.0%) (Table 2), fats and oils (e.g., butter, margarine) (25.9%) and savoury sauces and condiments (e.g., soy sauce, tomato sauce) (19.4%). A detailed breakdown of SCS is provided in the Supporting information (Table S1).

SCS contributed a median (IQR) of 286.4 kJ (81.8–626.5 kJ) or 3.8% (1.1%–7.9%) of total energy intake on the day of the recall (Table 3). In terms of macronutrient intakes, SCS contributed a median (IQR) of 5.3% (0.0–15.5) of fat intake, 2.3% (0.1–6.6) of carbohydrate intake and 0.2% (0.01–1.2) of protein intake.

### Contribution of SCS intakes to total energy and selected nutrient intakes

Percentage contribution of SCS to total energy and selected nutrient intakes by age and sex are presented in the Supporting information (Table S2). Among the macronutrients, SCS made the largest contribution to fat intakes for both females (5.7%) and males (4.9%) and the least contribution to protein intakes (0.2% for females and males). Among females, SCS contributed to 4.1% of saturated fat intakes, 4.6% of added sugars intake and 0.2% of fibre intake. Among males, SCS contributed to 3.2% of saturated fat intakes, 6.8% of



**TABLE 1** Demographics of the National Nutrition and Physical Activity Survey (NNPAS) respondents ( $n = 12,153$ )

	<i>N</i>	%
<b>Sex</b>		
Male	5702	46.9
Female	6451	53.1
<b>Age</b>		
2–3 years	464	3.8
4–8 years	789	6.5
9–13 years	787	6.5
14–18 years	772	6.4
19–30 years	1592	13.1
31–50 years	3565	29.3
51–70 years	2906	23.9
71+ years	1278	10.5
Born in Australia	9157	75.4
<b>Socio-Economic Index for Area (SEIFA)</b>		
Lowest quintile	2238	18.4
Highest quintile	2842	23.4
<b>Australian Statistical Geography Standard-Remoteness Area (ASGS-RA)</b>		
Major city	7788	64.1
Inner regional area	2376	19.6
Other	1989	16.4
<b>Day of the week of diet recall</b>		
Weekday	9546	78.5
Weekend day	2607	21.5
<b>Season of diet recall</b>		
Summer	3288	27.1
Autumn	3774	31.1
Winter	2768	22.8
Spring	2323	19.1
<b>Amount eaten on day of diet recall</b>		
Usual amount	9527	78.4
Much more than usual amount	839	6.9
Much less than usual amount	1781	14.7
Not stated	6	0.1

added sugars and 0.2% of fibre. Considering micronutrient intakes, SCS made the largest contribution towards vitamin E intakes for both females (median 3.6%) and males (median 3.4%), followed by sodium intakes for both females (median 3.0%) and males (median 2.9%). The median contribution of SCS to

vitamin C, riboflavin, thiamine and pyridoxine intakes was zero for both males and females.

## DISCUSSION

The results of the present study indicate that SCS contributed approximately 3.8% of total energy intake, 0.2%–5.3% of total macronutrient intakes and zero to 3.6% of selected total micronutrient intakes in the Australian population, using data from the most recent NNPAS. Contributions to energy, fat, including saturated fat, added sugars, vitamin E and sodium intakes were higher for some age and gender groups, meaning that SCS may have a more substantial contribution for some areas of diet and sectors of the population. The present study is an important addition to our overall understanding of dietary intakes among the Australian population, with relevance to other countries with similar dietary patterns.

SCS contributed a median of 3.8% of total daily energy intake in the current study, which increased with age, contributing 5.5% for older adults aged > 70 years. This is consistent with studies from the UK and New Zealand where it has been found that older adults are more likely to add SCS to meals.<sup>6,8</sup> Given appetite, food enjoyment and taste typically decline with age,<sup>19</sup> SCS may play a more important role in increasing energy intakes of older individuals. A study comparing energy and macronutrient intakes from meals with and without sauce and seasoning among older adults found higher intakes of energy, protein and fat when meals included sauce and/or seasoning than without.<sup>20</sup> This suggests that, regardless of the nutrient contribution of the SCS, these accompaniments may increase older adults' overall intake at the associated meal. This is important because energy intakes typically decline in older adulthood, with many consuming below energy requirements.<sup>21</sup> Age aside, if higher SCS intakes align with higher intake of nutrient rich foods, this may assist individuals across the lifespan to meet national dietary guidelines. In this case, the consumption of SCS is a positive and messaging around their intakes could focus on which are healthier and appropriate portion sizes.

Another key finding was that SCS contributed approximately 5.3% of total daily fat and 3.6% saturated fat intake, 2.3% of carbohydrate intake and negligible (0.2%) protein intake. The higher contribution to total and saturated fat intakes is in line with the data showing that one quarter of the SCS consumed were from the fats and oils group. Both fat type and quantity are important. National dietary guidelines recommend consuming a higher proportion of dietary fat from unsaturated food sources, relative to saturated fats. Given that Australian adults consume approximately 12% of total daily energy intake from saturated fat,<sup>1</sup> which exceeds the national target of 8%–10%, then 3.6% saturated fat from SCS in

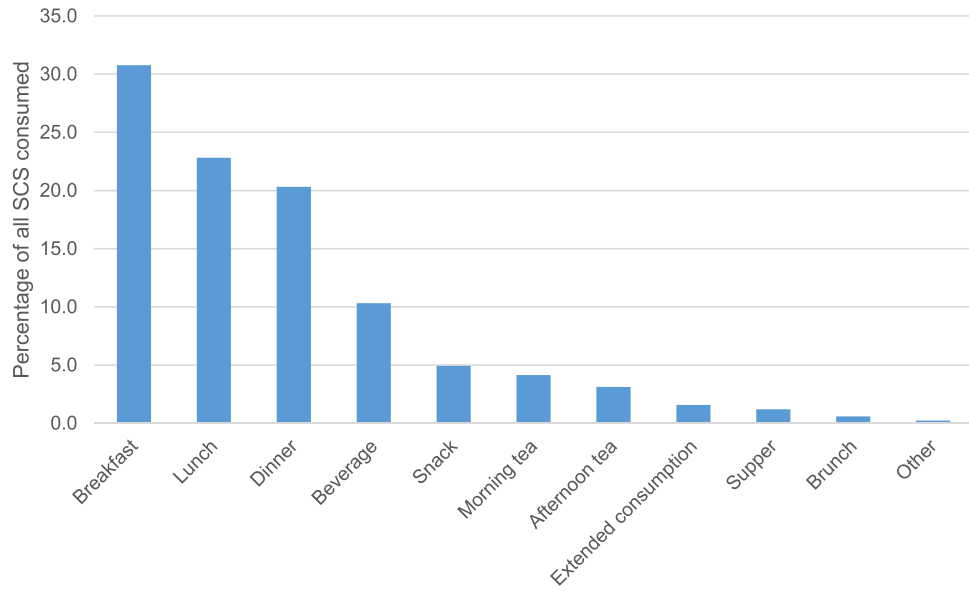


FIGURE 2 Distribution of sauces, condiments and seasonings (SCS) consumed by eating occasion

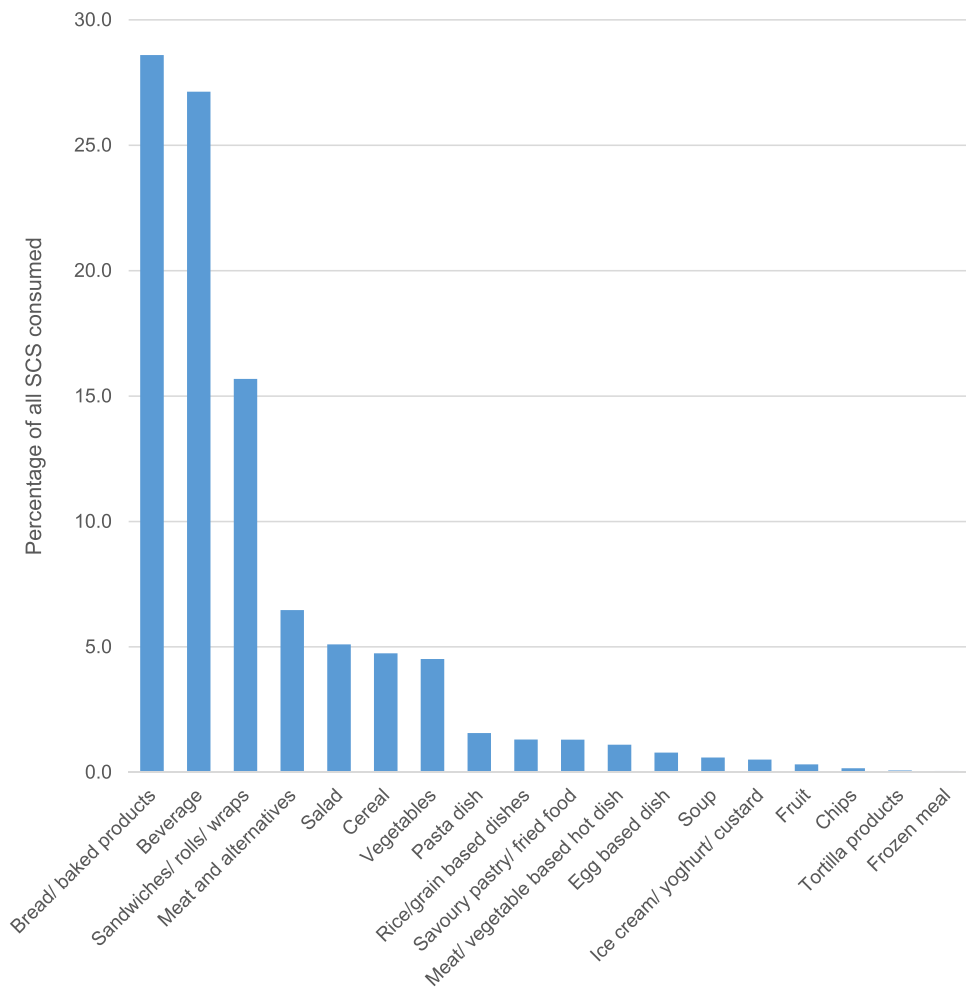


FIGURE 3 Distribution of sauces, condiments and seasonings (SCS) consumed by food combination type

TABLE 2 Proportion of SCS consumed by major food group<sup>a</sup>

Major food group	Examples of SCS <sup>b</sup>	N (%) of SCS per group
Sugar products and dishes	White sugar; honey; chocolate topping; strawberry jam; hazelnut and chocolate spread	10,684 (35.0)
Fats and oils	Plain salted butter; dairy blend spreads; polyunsaturated margarine spreads; olive oil	7920 (25.9)
Savoury sauces and condiments	Soy sauce; tomato sauce; barbeque sauce; mayonnaise; gravy; salad dressings; dips	5939 (19.4)
Miscellaneous	Vegemite; intense sweeteners; herbs and spices	4001 (13.1)
Milk products and dishes	Natural yoghurt; cream; sour cream; cream cheese	965 (3.2)
Seed and nut products and dishes	Peanut butter; satay sauce; coconut cream; coconut milk	605 (2.0)
Vegetable products and dishes	Fresh herbs; chilli	362 (1.2)
Non-alcoholic beverages	Lemon juice; lime juice; Milo; Nesquik	33 (0.1)
Meat, poultry and game products and dishes	Chicken liver pate; meat paste	32 (0.1)
Legume and pulse products and dishes	Bean paste	2 (0.01)

Abbreviation: SCS, sauces, condiments and seasonings.

<sup>a</sup>Major food groups as per AUSNUT 2011–2013 Food Composition Database.

<sup>b</sup>A detailed list of examples in order of most to least consumed within each minor food group is provided in the Supporting information (Table S1).

TABLE 3 Summary of energy and nutrients from sauces, condiments and seasonings in the National Nutrition and Physical Activity Survey (NNPAS) respondents on the day of the 24-h recall ( $n = 12,153$ )<sup>a</sup>

	Median (interquartile range)
Energy (kJ)	286.4 (81.8–626.5)
Percentage energy	3.8 (1.1–7.9)
Weight (g)	20.5 (6.0–42.8)
Percentage weight	0.7 (0.2–1.5)
Protein (g)	0.2 (0.01–0.9)
Percentage protein	0.2 (0.01–1.2)
Carbohydrates (g)	4.5 (0.1–13.5)
Percentage carbohydrates	2.3 (0.1–6.6)
Added sugars (g)	2.3 (0.0–9.8)
Percentage added sugars	5.7 (0.0–28.9)
Fat (g)	3.3 (0.0–9.8)
Percentage fat	5.3 (0.0–15.5)
Saturated fat (g)	0.8 (0.0–2.8)
Percentage saturated fat	3.6 (0.0–12.7)
Sodium (mg)	61.1 (0.7–216.1)
Percentage sodium	3.0 (0.04–10.0)
Fibre (g)	0.04 (0.0–0.4)
Percentage fibre	0.2 (0.0–1.9)

<sup>a</sup>Data are reported as totals of SCS rather than individually because the data were heavily skewed and median contributions for sauces and seasonings appear as zero. The main contributor to total intake of SCS was the condiments category. Percentages are of total daily intake.

the current study is important and may contribute to an increased risk of chronic conditions such as cardiovascular disease.<sup>18</sup> Reducing the amount of saturated fat consumed from SCS may be an important strategy for some individuals to reduce their total saturated fat intake and associated chronic disease risk, with evidence showing that sustained reduction of saturated fat intake may reduce the risk of cardiovascular events.<sup>22</sup> Furthermore, the contribution of sauce, condiments and seasonings to total energy intake may be an important consideration in terms of weight gain and chronic disease risk. Despite a relatively small contribution to total daily energy (286 kJ), studies have demonstrated that small, sustained energy increases can contribute to weight gain over time.<sup>23</sup>

SCS contributed approximately 6% of total added sugars, with a trend of increased contribution with age. Among older females (>70 years), the contribution of SCS to added sugars intake was 10.9%, whereas for older males it was 16.4%. No other studies have reported the contribution of added sugar from SCS to intake of total added sugars. SCS did not contribute a significant amount to added sugar intake based on medians; however, the interquartile ranges were large, with some individuals consuming over one third of their added sugar intakes from these food items. Considering that SCS can make up a large percentage of total added sugar intakes for some individuals and the health risks associated with excess intake of added sugars,<sup>24,25</sup> reducing the amount of added sugars in these items could be important for reducing total added sugar intakes at the population level.

In terms of micronutrient intakes, SCS were found to contribute the greatest proportion to vitamin E intakes

compared to other micronutrients. This is consistent with items from the fats and oils group being common condiments, given that vitamin E is a fat soluble vitamin. Approximately 3% of total daily sodium intakes were derived from SCS and, for some, such intakes were > 10%. The average daily intake of sodium of Australian adults is twice the suggested dietary target of 2000 mg, with intakes largely unchanged over the last 30 years based on meta-analytic findings.<sup>4</sup> Although 3% of sodium intake coming from SCS represents a relatively small proportion, strategies to reduce sodium intake across all areas of diet are needed to reduce the gap between target and actual intakes. This could be addressed at many levels, such as lower sodium reformulation targets in food processing, as well as health promotion messaging at the population level and also targeted to individuals to consciously choose lower/reduced and no added salt options. SCS made no contribution to median intakes of vitamin C, riboflavin, thiamine and pyridoxine for both males and females in the present study. However, this is likely a result of the heavily skewed data rather than reflecting a true zero contribution. If at all, the contribution to intake of these nutrients appears to be minimal.

The present study has some limitations. Although the percentage contribution of SCS to the dietary indicators studied is relatively small, the actual quantity of SCS consumed was small on average. It is possible that under-reporting of these food items occurred because previous studies have reported that sauces and condiments are commonly forgotten items in food recalls.<sup>26,27</sup> Unintentional under-reporting of sauces and condiments may explain in part the small contribution of these items to dietary indicators. However, even if this is taken into consideration, the main implication of the present study for research and practice is that SCS are potentially important contributors to daily energy intakes and some nutrient intakes among certain sectors of the population (e.g., older adults). Further exploration is needed to determine which SCS contribute most to specific nutrients for specific population groups. The heavily skewed data also have limitations in that medians of zero contributions for certain nutrients were identified.

The major strength of the present study is that this is the first to analyse SCS contributions to nutrient intakes in a high level of detail. A further strength is the use of a nationally representative dataset with a large sample size. The 24-h recall method for collection of dietary intake data is appropriate to provide a snapshot of SCS intakes in line with the aims of this analysis. Comprehensive methods were used to define and categorise SCS and their intake in the present study.

## CONCLUSIONS

SCS are small contributors to overall energy and nutrient intakes in the Australian population. However, this varies by age and gender and for some (e.g, older adults),

SCS may have a more substantial contribution to both positive and negative aspects of food and nutrient intakes.

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## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

## AUTHOR CONTRIBUTIONS

Clare E. Collins, Megan Whatnall, Megan E. Rollo and Tracy Schumacher conceptualised the research aims. All authors contributed to discussion on the definitions and methodology used. Megan Whatnall and Erin D. Clarke coded the dietary data and conducted analyses, with assistance from Tracy Schumacher and Clare E. Collins. Megan Whatnall and Erin D. Clarke drafted the original manuscript. All authors contributed to the interpretation of the results and critically reviewed the manuscript. All authors have reviewed and approved the final manuscript and accept full responsibility for all aspects of the work described.

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with STROBE-nut guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Associations of HIV and iron status with gut microbiota composition, gut inflammation and gut integrity in South African school-age children: A two-way factorial case–control study

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## Abstract

**Background:** Human immunodeficiency virus (HIV) and iron deficiency (ID) affect many African children. Both HIV and iron status interact with gut microbiota composition and related biomarkers. The study's aim was to determine the associations of HIV and iron status with gut microbiota composition, gut inflammation and gut integrity in South African school-age children.

**Methods:** In this two-way factorial case–control study, 8- to 13-year-old children were enrolled into four groups based on their HIV and iron status: (1) With HIV (HIV+) and ID ( $n = 43$ ), (2) HIV+ and iron-sufficient nonanaemic ( $n = 41$ ), (3) without HIV (HIV–) and ID ( $n = 44$ ) and (4) HIV– and iron-sufficient nonanaemic ( $n = 38$ ). HIV+ children were virally suppressed ( $<50$  HIV RNA copies/ml) on antiretroviral therapy (ART). Microbial composition of faecal samples (16S rRNA sequencing) and markers of gut inflammation (faecal calprotectin) and gut integrity (plasma intestinal fatty acid-binding protein [I-FABP]) were assessed.

**Results:** Faecal calprotectin was higher in ID versus iron-sufficient nonanaemic children ( $p = 0.007$ ). I-FABP did not significantly differ by HIV or iron status. ART-treated HIV (redundancy analysis [RDA]  $R^2 = 0.009$ ,  $p = 0.029$ ) and age (RDA  $R^2 = 0.013$   $p = 0.004$ ) explained the variance in the gut microbiota across the four groups. Probabilistic models showed that the relative abundance of the butyrate-producing genera *Anaerostipes* and *Anaerotruncus* was lower in ID versus iron-sufficient children. *Fusicatenibacter* was lower in HIV+ and in ID children versus their respective counterparts. The prevalence of the inflammation-associated genus *Megamonas* was 42%

**Abbreviations:** 3TC, lamivudine; ABC abacavir; AGP,  $\alpha$ -1-acid glycoprotein; ANCOVA, analysis of covariance; ART, antiretroviral therapy; ASV, Amplicon Sequence Variants; ATV/r, atazanavir boosted with ritonavir; AZT, zidovudine; BRINDA, Biomarkers Reflecting Inflammation and Nutritional Determinants of Anaemia; CRP, C-reactive protein; EFV, efavirenz; FTC, emtricitabine; Hb, haemoglobin; HDI, highest density intervals; HIV, human immunodeficiency virus; HIV–, living without HIV; HIV+, living with HIV; ID, iron deficiency; I-FABP, intestinal fatty acid-binding protein; IQR, interquartile range; LPV/r, lopinavir boosted with ritonavir; NNRTI, non-nucleoside reverse-transcriptase inhibitor; NRTI, nucleoside reverse-transcriptase inhibitors; NVP, nevirapine; PCoA, principal coordinate analysis; PF, plasma ferritin; PI/r, ritonavir-boosted protease inhibitor; RDA, redundancy analysis; SD, standard deviation; sTfR, soluble transferrin receptor; TDF, tenofovir.

Charlene Goosen and Sebastian Proost have contributed equally to this study.

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higher in children with both HIV and ID versus HIV- and iron-sufficient nonanaemic counterparts.

**Conclusions:** In our sample of 8- to 13-year-old virally suppressed HIV+ and HIV- children with or without ID, ID was associated with increased gut inflammation and changes in the relative abundance of specific microbiota. Moreover, in HIV+ children, ID had a cumulative effect that further shifted the gut microbiota to an unfavourable composition.

**KEYWORDS**

gut microbiota, HIV, inflammation, iron deficiency, school-age children, South Africa

**Key points**

1. Iron deficiency (ID) was associated with higher gut inflammation measured by faecal calprotectin.
2. Gut mucosal integrity measured by intestinal fatty acid-binding protein did not differ by human immunodeficiency virus (HIV) or iron status.
3. In HIV+ children, ID had a cumulative effect that promoted an unfavourable gut microbiota composition.

**INTRODUCTION**

Globally, ~37.7 million people are living with human immunodeficiency virus (HIV+), and two-thirds of this population are from sub-Saharan Africa. The number of HIV+ children <15 years is estimated at 1.7 million, of whom 310,000 (18%) are from South Africa.<sup>1</sup> In many African countries, an additional challenge is malnutrition, with 52% of African children estimated to be iron deficient.<sup>2</sup> Because HIV is associated with chronic systemic inflammation,<sup>3-5</sup> HIV+ children are more vulnerable to iron deficiency (ID) than children without HIV (HIV-). Systemic inflammation can down-regulate iron absorption, adversely affect iron status and cause anaemia of inflammation.<sup>6</sup> This is especially detrimental in resource-poor settings where iron intake from plant-based diets is low and poorly bioavailable, which in turn causes nutritional anaemia.<sup>7</sup>

The interplay between colonic iron availability and compositional changes in the gut microbiota has become a topic of interest, though more frequently discussed in the context of an iron surplus. However, *in vitro* colonic fermentation and animal studies have found that very low colonic iron conditions significantly alter gut bacteria composition and function, especially butyrate producers and short-chain fatty acid metabolism.<sup>8,9</sup> A potential explanation is that enzymes in the butyrate production pathway are iron dependent.<sup>10</sup> It is unclear whether these findings are applicable to ID children, where complex human-microbiota interactions and fine regulation of iron absorption come into play.

The gut is also the compartment most persistently affected by HIV in the long term, despite viral suppression. Soon after HIV infection, the gut-associated lymphoid tissue is severely depleted of CD4+ T cells, including T17 helper cells that are essential to maintain the gut mucosal

barrier.<sup>11</sup> The early loss of CD4+ T cells marks the beginning of HIV-associated enteropathy.<sup>12</sup> Although antiretroviral therapy (ART) suppresses HIV replication and reverses CD4+ T-cell depletion in the peripheral blood compartment, its kinetics are slower in the gut mucosa. This leads to unsuccessful or partial replenishment of the gut environment. Consequences of HIV-associated enteropathy include gut inflammation and increased intestinal permeability, despite ART.<sup>13</sup> A loss of gut mucosal integrity could facilitate microbial translocation, with chronic immune activation, poorer restoration of CD4+ T cells and disturbances of the host-microbiota homeostasis as potential consequences.<sup>14-16</sup>

Studies suggest that ART alters gut microbiota composition to a bacterial community structure distinct from HIV-, as well as ART-naive HIV+ reference groups.<sup>16,17</sup> In HIV+ populations, gut microbiota composition appears to shift towards higher proportions of proinflammatory and lower proportions of anti-inflammatory bacterial species.<sup>16,18,19</sup> This state of dysbiosis promotes pathogenic and inflammatory pathways.<sup>20,21</sup>

Current and future paediatric HIV populations will increasingly receive ART from early infancy. Thus, understanding the effects of prolonged ART exposure is becoming more important. Both HIV and iron status interact with gut inflammation, gut integrity and microbiota composition, yet to our knowledge, associations between iron status and gut health in the context of HIV have not been studied. Considering the high burden of HIV and ID in sub-Saharan Africa, it is important to examine the relationship of both HIV and iron status with gut health, as well as the potential interactions between HIV and iron status. Therefore, the aim of this study was to determine the associations of HIV and iron status with gut microbiota

composition, gut inflammation and gut integrity in South African school-age children.

## METHODS

### Study design and participants

This two-way factorial case–control study was performed within a cohort of 8- to 13-year-old HIV+ and HIV– children at the Family Centre for Research with Ubuntu in Cape Town, South Africa.<sup>22</sup> Children were eligible if they reported no recent acute illness, if they reported no iron supplementation use in the past 3 months and, in the HIV+ children, if they were virally suppressed (<50 HIV RNA copies/ml plasma) based on routine annual monitoring data obtained from the National Health Laboratory Service electronic portal. In HIV– children, the absence of HIV was confirmed using a rapid HIV assay (First Response HIV Card 1–2.0, Premier Medical Corporation Pvt Ltd). Children were excluded if severely underweight or obese (body-mass-index-for-age Z-score <–3 or >2)<sup>23</sup> and severely anaemic (haemoglobin [Hb] <80 g/L).<sup>7</sup> Screening measurements included serum ferritin and Hb, and based on their HIV and iron status, 180 children were enrolled in the following four groups: (1) HIV+ and ID (*n* = 45), (2) HIV+ and iron-sufficient nonanaemic (*n* = 45), (3) HIV– and ID (*n* = 45) and (4) HIV– and iron-sufficient nonanaemic (*n* = 45). For enrolment purposes, ID was defined as inflammation-unadjusted ferritin ≤40 µg/L, iron sufficiency as unadjusted ferritin >40 µg/L and the absence of anaemia as Hb ≥115 g/L.

For this present study, further exclusion criteria included (1) detectable HIV viral load, (2) antibiotic use in the 4 weeks prior to faecal sample collection, (3) probiotic use 1 week prior to faecal sample collection, (4) vegetarianism or veganism and (5) self-reported gastrointestinal disorders. HIV viral load was measured (Roche COBAS AmpliPrep/TaqMan HIV-1 Test, v2, Hoffmann-La Roche, Basel, Switzerland), and six children were excluded because of viral loads ≥50 copies/ml. Three children were excluded because of antibiotic use. Of the remaining 171 children, 5 children provided an insufficient faecal sample for the necessary measurements, resulting in a final subsample of 166 children. The number of participants per group was (1) HIV+ and ID (*n* = 43), (2) HIV+ and iron-sufficient nonanaemic (*n* = 41), (3) HIV– and ID (*n* = 44) and (4) HIV– and iron-sufficient nonanaemic (*n* = 38). Based on the two-way factorial design and assuming 80% power and a type I error rate of 5%, the final sample size allowed us to detect an effect size of 0.3 between groups.

Participant, socio-demographic, anthropometric, dietary intake, anaemia, iron status and systemic inflammation indicators were collected with the using detailed methods previously described.<sup>22</sup> In brief, socio-demographic and

HIV information was obtained using a structured questionnaire, and weight and height were measured using a Micro 1023 electronic platform scale and stadiometer (Scalerite) and standardised techniques.<sup>24</sup> Habitual dietary intake information was collected using an abbreviated quantified food frequency questionnaire. The questionnaire was developed for the specific study population using a methodical multiphase approach with the using details previously described.<sup>25</sup> Hb concentrations were measured in whole blood using a Siemens Advia 2120i Haematology System (Siemens), and plasma ferritin (PF), soluble transferrin receptor (sTfR), C-reactive protein (CRP) and  $\alpha$ -1-acid glycoprotein (AGP) were measured using a multiplex immunoassay.<sup>26</sup> PF values were adjusted for inflammation using the Biomarkers Reflecting Inflammation and Nutritional Determinants of Anaemia (BRINDA) correction approach.<sup>27</sup> This approach uses linear regression to adjust PF using the CRP and AGP concentrations. Intestinal fatty acid-binding protein (I-FABP) was measured using an ELISA (enzyme-linked immunosorbent assay) immunoassay (Hycult Biotech).

### Faecal sample collection and analyses

Faecal samples were collected at home the night or morning before the study visit. The children received a lined plastic container with a lid that sealed airtight and an Oxoid™ AnaeroGen™ 2.5-L Sachet (Thermo-Fisher Scientific Inc.) to generate an anaerobic environment in the container after sample deposit. A cooler bag, icepacks and illustrated instructions in their home language were provided in addition. On the day of the visit, stool samples were aliquoted and frozen at –70°C for the calprotectin and gut microbiota analyses. Faecal calprotectin was measured using an ELISA immunoassay (Eurospital). Elevated gut inflammation was classified as faecal calprotectin >200 µg/g.<sup>28</sup>

### DNA extraction, library preparations and sequencing

DNA extraction was performed using the MagAttract PowerMicrobiome DNA/RNA Kit (Qiagen). For microbiota analysis, the V4 region of the 16S rRNA gene was amplified with the primer pairs 515F and 806R (GTGY CAGCMGCCGCGGTAA and GGACTACNVGGG TWTCTAAT, respectively), modified to contain a barcode sequence between each primer and the Illumina adaptor sequences to produce dual-barcoded libraries. Followed by size selection using Agencourt AMPure to remove fragments below 200 bases, 16S rRNA sequencing was performed on an Illumina MiSeq platform (MiSeq Reagent Kit v2, 500 cycles, 15.38% PhiX, 2 × 250 PE) at the VIB Nucleomics core laboratory (Leuven, Belgium).



De-multiplexing was performed using LotuS. This was followed by quality inspection; the removal of chimeras, primers and the first 10 bases following the primer; and the merging of paired sequences using DADA2 (v1.6). The resulting sequences were further grouped into Amplicon Sequence Variants (ASV).<sup>29</sup> Finally, taxonomy was assigned to all ASVs (using Ribosomal Database Project's trainset 16) and agglomerated to genus level.

## Statistical analysis

### Participant characteristics and gut health markers

Statistical analyses were performed using IBM SPSS Statistic software, version 27 (IBM Corp.). Normally distributed continuous variables were described using means and standard deviations (SD), non-normally distributed variables with medians and interquartile ranges and categorical variables with frequencies and percentages. Non-normally distributed outcome variables were log-transformed prior to analysis. The characteristics of the four groups were compared using two-way factorial analysis of variance for continuous variables and two-way binary logistic regression for categorical variables. The associations of HIV and iron status with gut health markers were assessed using two-way factorial analysis of covariance (ANCOVA) for continuous outcome variables and two-way binary logistic regression for categorical outcome variables, adjusting for age, sex, ethnicity and deworming. If the ANCOVA or logistic regression did not show a significant interaction effect, it was repeated without the interaction factor. In the case of a significant interaction effect (observed only for a categorical outcome variable in this study), between-group differences were analysed using a  $\chi^2$  test with Bonferroni adjustment for multiple comparisons. Statistical significance was set at  $p < 0.05$ .

### Gut microbiota

Statistical analyses were performed using R statistical software (<http://www.r-project.org/>). Genera with low prevalence (detected in less than 20% of the samples) were excluded from the analysis. The  $\alpha$ -diversity for each sample was calculated using the Shannon diversity index upon the rarefied abundances. A principal coordinate analysis (PCoA), using the Bray–Curtis distance, was carried out on 16S rRNA gene abundances after aggregating counts at the genus level (using DADA2). The Kruskal–Wallis test with post hoc Dunn's test (with  $fdr\_bh$  to correct for multiple testing) was used to test median differences of  $\alpha$ - and  $\beta$ -diversity between groups. Enterotypes were obtained by combining 16S rRNA gene data from this sample with data from the Flemish

Gut Flora Project<sup>30</sup> and applying an approach based on Dirichlet multinomial mixtures.<sup>31</sup>

Redundancy analysis (RDA) was used to identify variables in the metadata that explained the variance in gut microbiota composition between the four groups. The independent effect size of significant variables on microbial composition was determined using the function *capscale* (using Euclidean distance on centred log-ratio-transformed abundance data), part of the *vegan* package, whereas the nonredundant effect was obtained combining the *rda* and *ordiR2step* from the same package. Statistical significance was set at a false discovery rate  $< 0.1$ . To force a feature to be considered before others, this procedure is split into two steps: first, *ordiR2step* is run with a null model (without features) to a model with features that need to be accounted first (HIV status in this study – see ‘Results’ section). Next, *ordiR2step* is run again starting from the model with the forced features to the model with all features. Finally, the output from both runs is merged.

To assess the associations of HIV and iron status with various genera, a probabilistic model was used implemented in Python (version 3.10.5) with PyMC (version 4.0.0).<sup>32</sup> Here five models, based on negative binomial distributions, with various degrees of complexity, were used. The simplest model contains a single feature ( $p_{base}$ ) to model the number of reads found from a given genus in all samples which is used with a binomial likelihood. For more complex models, additional features ( $m_{hiv}$ ,  $m_{id}$  and  $m_{interaction}$ ) that allow HIV and iron status to affect the binomial likelihood's probability  $p$  were included.

Given HIV and iron status are encoded as 0 or 1 (for absent and present, respectively), the models' probabilities were defined as follows:

- $p = p_{base}$
- $p = p_{base} + m_{hiv} \times \text{HIV status}$
- $p = p_{base} + m_{id} \times \text{iron status}$
- $p = p_{base} + m_{hiv} \times \text{HIV status} + m_{id} \times \text{iron status}$
- $p = p_{base} + m_{hiv} \times \text{HIV status} + m_{id} \times \text{iron status} + m_{interaction} \times (\text{HIV status} \times \text{iron status})$

All five models were run on all genera using PyMC's No-U-Turn sampler<sup>33</sup> with 4000 samples, 2000 tuning steps and 4 chains. Noninformative priors were used for all features. For each genus, the simplest model with the best fit was selected by visual inspection of the model performance using the function *plot\_compare* from ArViz (version 0.12.1).<sup>34</sup> Genera where either HIV or iron status was retained as a component of the model were considered for further analysis. Probability density functions and highest density intervals (HDI) for the models inspected in detail were generated using *plot\_trace* and *summary* from the ArViz package.

To assess if a difference in the prevalence of participants with *Megamonas* better explained our



observations for that genus than differences in abundance between participant groups, another model was used. In this model each of the four groups was assigned two weights  $w$  for participants with and without *Megamonas* using a Dirichlet distribution with a flat prior. Two possible binomial distributions, one with the probability of success set to zero (for participants lacking the genus) and the other with the success probability set to a variable  $p_{\text{base}}$  (from a HalfNormal distribution with sigma 0.001), were combined with the weights  $w$  for each group and compared with the data using a mixture likelihood. Deterministic variables were set to extract the difference in prevalence of participants with *Megamonas* between HIV- and iron-sufficient nonanaemic participants and participants from the other groups. Sampling was performed using the same settings as the previous analysis except for the parameter *target\_accept* which was increased to 0.9.

All figures for this study were generated using Python 3.10.5 with Seaborn 0.11.2 and Matplotlib 3.5.1. Statsannotations 0.4.4 was used to include results from statistical tests in box plots.

## RESULTS

### Participant characteristics

Participant characteristics are summarised in Table 1. Compared with HIV- children, HIV+ children were from smaller households ( $p = 0.040$ ) had lower height-for-age Z-scores ( $p < 0.001$ ), and higher sTfR levels ( $p = 0.001$ ), CRP ( $p = 0.007$ ) and AGP concentrations ( $p = 0.031$ ). HIV+ children reported lower intake of animal protein ( $p < 0.001$ ) and haem iron ( $p = 0.002$ ) compared with HIV- children. Compared with iron-sufficient nonanaemic children, more ID children received care from a single primary caregiver ( $p = 0.028$ ). isiXhosa African children comprised 43% of the study population, and 57% of the children were of Capetonian mixed ancestry. The proportions of these two ethnic groups differed significantly between groups, with fewer isiXhosa African children in the HIV- iron-sufficient nonanaemic group compared with the other three groups. Of all children, 96% had been dewormed in the past 6 months. In the HIV+ children, ritonavir-boosted protease-inhibitor-based ART regimens were more common (71%) than non-nucleoside reverse-transcriptase inhibitor-based regimens (29%).

### Gut inflammation and gut integrity

Table 2 presents the measured gut health-related biomarkers. Faecal calprotectin was significantly higher in ID children than in iron-sufficient nonanaemic children ( $p = 0.007$ ). I-FABP did not significantly differ by HIV or iron status.

### Gut microbiota composition

There was a high relative abundance of *Prevotella* in all four groups (Figure 1a). This was also observed during enterotyping, with 96.4% of all children presenting as the *Prevotella* enterotype and 3.6% as the *Bacteroides 2* enterotype. The PCoA (Figure 1b) revealed that along the first axis there was little variation between the four groups. However, along the second axis there was a clear downward shift for HIV+ samples, with samples from ID children spread out more. There were no significant differences in  $\alpha$ -diversity between the four groups ( $p = 0.99$ ) (Figure 1c).  $\beta$ -diversity (inter-individual differences) based on mean Bray-Curtis distances was significantly higher in HIV+ than in HIV- children ( $p < 0.001$ ) (Figure 1d). Because all HIV+ children were on ART, the effects of HIV status and ART cannot be uncoupled in this analysis.

The RDA, which unveils features in the metadata that drive variation in the microbiota, revealed that from a total of 35 variables (Supporting Information, Supplementary Table 1a and b), age was the only microbiota covariate (RDA  $R^2 = 0.016$ ,  $p = 0.008$ ). However, age showed a borderline difference ( $p = 0.06$ ) by HIV status in this sample and may therefore capture some of the same variation as ART-treated HIV. HIV status, when forced for first consideration, was a significant factor from the metadata (RDA  $R^2 = 0.009$ ,  $p = 0.029$ ), and age remained a significant factor (RDA  $R^2 = 0.013$ ,  $p = 0.004$ ).

Using probabilistic models with various degrees of complexity (see 'Methods' section), we examined the associations of HIV and iron status with the gut microbiota. Table 3 presents the differences in relative abundance explained by HIV status only (with no iron-status effect). In contrast with traditional statistical methods, probabilistic methods do not provide  $p$ -values but aim to generate a distribution of plausible values for a given parameter of interest. These distributions can be summarised by the smallest interval that contains 94% of those plausible values, the highest density interval (HDI) along with the mean and SD of those values.

Models convincingly show that the relative abundances of *Anaerostipes* (Figure 2a) and *Anaerotruncus* (Figure 2b) shift by iron status but not by HIV status. The relative abundance of *Anaerostipes* and *Anaerotruncus* was  $45\% \pm 1$  (HDI 43–47) and  $56\% \pm 2$  (HDI 52–60) lower, respectively, in children with ID. *Fusicatenibacter* (Figure 2c) differed by HIV status and by iron status but with no interaction effect. *Fusicatenibacter* was  $29\% \pm 1$  (HDI 27–30) and  $35\% \pm 1$  (HDI 34–37) lower in children with HIV and in children with ID, respectively. There was an HIV  $\times$  iron status interaction effect for *Megamonas* (Figure 2d). Given the low prevalence of *Megamonas*, an alternative model was tested. This model assumes a constant abundance across the different groups; however, the prevalence of people carrying

TABLE 1 Characteristics of the four groups of South African children enrolled based on HIV and iron status.

	HIV+ and ID <i>n</i> = 43	HIV+ and iron-sufficient nonanaemic <i>n</i> = 41	HIV- and ID <i>n</i> = 44	HIV- and iron-sufficient nonanaemic <i>n</i> = 38	HIV	<i>p</i> -Values* Iron status	HIV × iron status
<i>Participant information</i>							
Age (y), median (IQR)	11.6 (9.8–12.5)	11.4 (10.8–12.4)	11.2 (9.7–12.3)	10.6 (9.5–12.2)	0.06	0.94	0.23
Male/female, <i>n</i> (%)	20 (47)/23 (54)	27 (66)/14 (34)	21 (48)/23 (52)	20 (53)/18 (47)	0.46	0.12	0.34
isiXhosa African/Cape-tonian mixed ancestry, <i>n</i> (%) <sup>†</sup>	18 (42)/25 (58) <sub>a</sub>	27 (66)/14 (34) <sub>a</sub>	23 (52)/21 (48) <sub>a</sub>	3 (8)/35 (92) <sub>b</sub>	0.33	0.029	<0.001
Dewormed in the past 6 months, <i>n</i> (%)	40 (93)	40 (98)	43 (98)	37 (97)	0.42	0.47	0.50
HIV RNA (copies/ml)	<50	<50	–	–	–	–	–
Age at antiretroviral therapy start (y), median (IQR)	1.0 (0.0–2.5)	1.0 (0.0–1.0)	–	–	–	0.94	–
NNRTI-based/PI/r-based, <i>n</i> (%) <sup>‡</sup>	14 (33)/29 (67)	10 (24)/30 (73)	–	–	–	0.45	–
<i>Household information</i>							
Formal/informal housing, <i>n</i> (%) <sup>§</sup>	26 (61)/17 (40)	23 (56)/18 (44)	30 (68)/14 (32)	26 (68)/12 (32)	0.19	0.78	0.77
Number of household members, median (IQR)	5 (4–6)	5 (4–6)	6 (4–7)	6 (5–7)	0.040	0.47	1.00
Primary caregiver single/in partnership, <i>n</i> (%)	24 (56)/19 (44)	16 (39)/25 (61)	19 (43)/25 (57)	10 (26)/28 (74)	0.09	0.028	0.91
Breadwinner unemployed, <i>n</i> (%)	20 (47)	17 (42)	22 (50)	10 (26)	0.48	0.06	0.20
<i>Anthropometry</i>							
Height-for-age Z-score, mean ± SD	−1.4 ± 1.0	−1.1 ± 0.9	−0.7 ± 1.0	−0.4 ± 0.9	<0.001	0.12	0.98
Body-mass-index-for-age Z-score, mean ± SD	−0.4 ± 1.0	−0.4 ± 1.0	−0.2 ± 1.2	−0.1 ± 1.0	0.12	0.70	0.57
<i>Anaemia and iron status</i>							
Haemoglobin (g/L), mean ± SD	119 ± 11	126 ± 8	121 ± 8	124 ± 8	0.74	<0.001	0.23
Plasma ferritin (adjusted for inflammation) (µg/L), <sup>1</sup> median (IQR)	17 (13–27)	38 (27–66)	20 (17–26)	35 (27–49)	0.88	<0.001	0.07
Soluble transferrin receptor (mg/L), median (IQR)	7.0 (6.0–8.9)	7.0 (5.4–8.7)	6.5 (5.8–7.2)	6.1 (5.3–6.9)	0.001	0.23	0.41
<i>Systemic inflammation</i>							
C-reactive protein (mg/L), median (IQR)	0.12 (0.02–1.14)	0.04 (0.03–1.04)	0.04 (0.02–0.35)	0.04 (0.02–0.43)	0.007	0.73	0.89
α-1-acid glycoprotein (g/L), median (IQR)	0.6 (0.5–0.8)	0.6 (0.4–0.9)	0.5 (0.4–0.8)	0.5 (0.4–0.7)	0.031	0.78	0.47
<i>Selected daily nutrient intake</i>							
Total protein (g), median (IQR)	69 (53–76)	62 (52–76)	80 (62–98)	81 (66–102)	0.003	0.73	0.47
Animal protein (g), median (IQR)	32 (22–39)	27 (21–37)	40 (26–51)	44 (34–64)	<0.001	0.55	0.15
Plant protein (g), median (IQR)	34 (29–45)	35 (25–42)	36 (30–45)	34 (22–41)	0.69	0.07	0.69
Total iron (mg), median (IQR)	16 (14–21)	17 (14–21)	18 (15–21)	17 (13–22)	0.84	0.19	0.92
Haem iron (mg), median (IQR)	2.3 (1.6–4.0)	2.0 (1.5–3.4)	3.3 (2.0–4.3)	3.2 (2.5–5.1)	0.002	1.00	0.19
Nonhaem iron (mg), median (IQR)	13 (12–18)	14 (11–17)	15 (12–17)	12 (9–18)	0.44	0.13	0.73
Total fibre (g) median (IQR)	25 (20–31)	25 (19–30)	28 (22–36)	25 (18–36)	0.32	0.12	0.90

Abbreviations: HIV, human immunodeficiency virus; ID, iron deficient; IQR, interquartile range; NNRTI, non-nucleoside reverse-transcriptase inhibitor; PI/r, ritonavir-boosted protease inhibitor; SD, standard deviation.

\*Non-normally distributed outcome variables were log-transformed prior to analysis. Associations of the factors HIV and iron status with household and socio-demographic characteristics were assessed using two-way analysis of variance for continuous variables and two-way logistic regression analysis for categorical variables.

<sup>†</sup>Between-group differences were analysed using a  $\chi^2$  test with Bonferroni adjustment for multiple comparisons. Values in a row without a common letter (a, b) differ significantly ( $p < 0.05$ ).

<sup>‡</sup>HIV+ and iron-sufficient nonanaemic ( $n = 40$ ), incomplete information. All regimens included two nucleoside reverse-transcriptase inhibitors (NRTIs) in combination with either a non-nucleoside reverse-transcriptase inhibitor (NNRTI-based) or a ritonavir-boosted protease inhibitor (PI/r-based). NRTIs included abacavir (ABC), lamivudine (3TC), zidovudine (AZT), tenofovir (TDF) and emtricitabine (FTC); NNRTIs included efavirenz (EFV) and nevirapine (NVP); and PIs included lopinavir boosted with ritonavir (LPV/r) and atazanavir boosted with ritonavir (ATV/r).

<sup>§</sup>Formal housing represents a brick house, whereas informal housing represents a Wendy house or dwelling built with scrap building material and typically not equipped with water and/or electricity.

<sup>1</sup>Plasma ferritin adjusted for inflammation using the Biomarkers Reflecting Inflammation and Nutritional Determinants of Anaemia correction approach.<sup>27</sup>

TABLE 2 Gut inflammation and gut integrity.

	HIV+ and ID n = 43	HIV+ and iron-sufficient nonanaemic n = 41	HIV- and ID n = 44	HIV- and iron-sufficient nonanaemic n = 38	HIV	Iron status	HIV × iron status	p-Values <sup>a</sup>
Faecal calprotectin (µg/g) median (IQR) <sup>b</sup>	22 (7–57)	6 (3–18)	20 (3–75)	5 (1–50)	0.85	0.006	0.77	
50–200 µg/g, n (%)	7 (17)	4 (10)	8 (18)	7 (18)	0.36	1.00	0.36	
>200 µg/g, n (%)	4 (10)	4 (10)	5 (11)	2 (5)	0.99	0.50	0.45	
Intestinal fatty acid-binding protein (pg/ml), median (IQR)	859 (482–1164)	799 (366–1110)	633 (457–1010)	935 (603–1219)	0.47	0.44	0.09	

Abbreviations: HIV, human immunodeficiency virus; ID, iron deficient; IQR, interquartile range.

<sup>a</sup>Non-normally distributed outcome variables were log-transformed prior to analysis. Associations of the factors HIV and iron status with gut health markers were assessed using two-way analysis of covariance for continuous variables and two-way logistic regression analysis for categorical variables, adjusting for age, sex, ethnicity and deworming.

<sup>b</sup>Total study population n = 162, HIV+ and ID n = 42, HIV+ and iron-sufficient nonanaemic n = 39 and HIV- and ID n = 43, because insufficient stool sample sizes were provided in four cases.

*Megamonas* can differ between groups. This was a better fit for our data than the previous model, and although we cannot confidently say that *Megamonas* prevalence is affected by HIV or iron status alone, the prevalence was 42% ± 9 (HDI 25%–59%) higher in children with both HIV and ID than in HIV- and iron-sufficient nonanaemic counterparts.

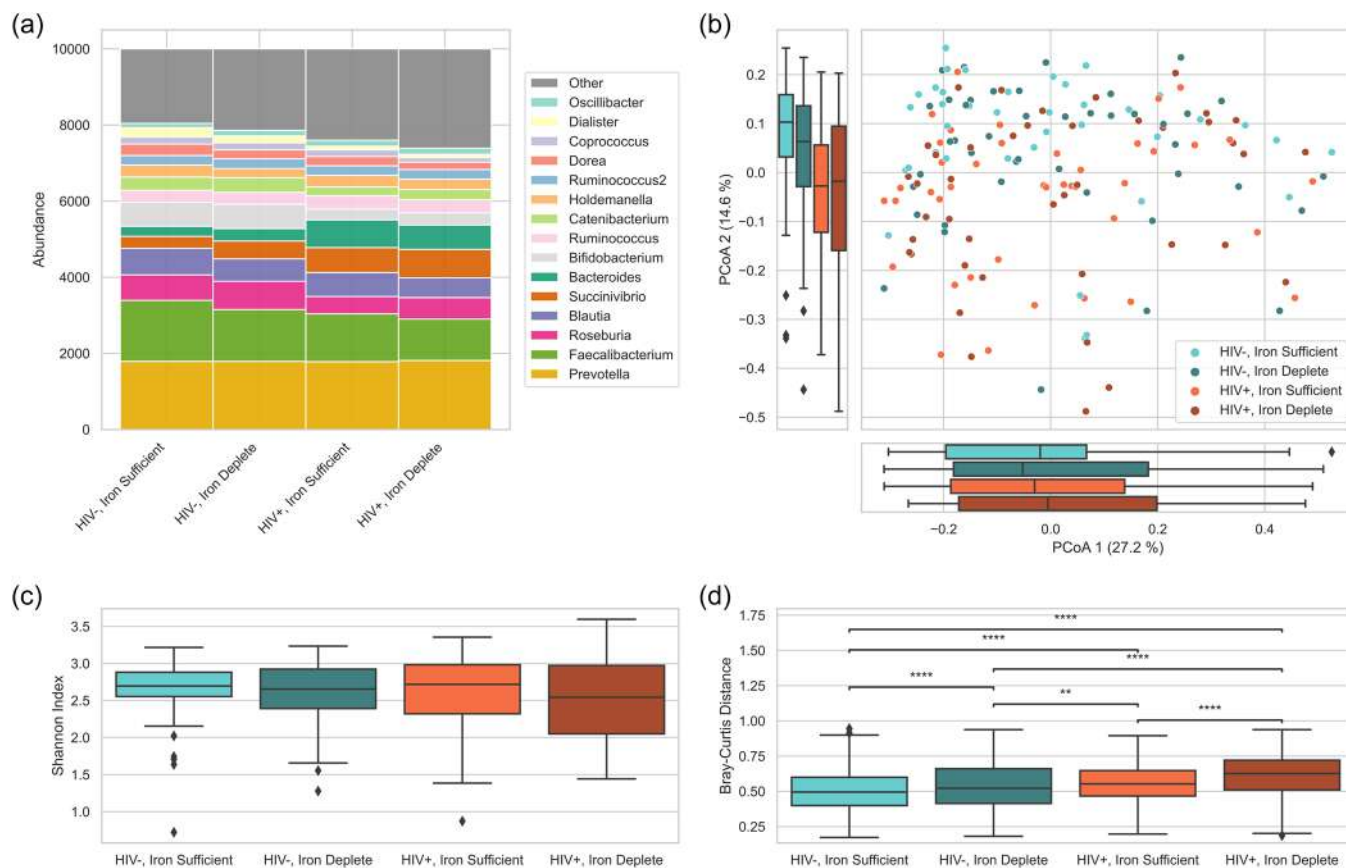
## DISCUSSION

Our aim was to better comprehend the associations of HIV and iron status with the gut health of 8- to 13-year-old South African children. We found that gut mucosal integrity and gut microbial  $\alpha$ -diversity measures did not significantly differ by HIV or iron status. ID was associated with higher gut inflammation, and both HIV and ID were associated with higher gut microbial  $\beta$ -diversity. ART-treated HIV and age explained the variance in gut microbiota composition across the four groups. In the HIV+ children, the relative abundance of 15 microbial genera was higher and that of 12 microbial genera was lower than in the HIV- children. In ID children, the relative abundance of *Anaerostipes*, *Anaerotruncus* and *Fusicatenibacter* was lower than in the iron-sufficient nonanaemic children. There was an HIV × iron status interaction effect for *Megamonas*, and the prevalence-based model confidently demonstrated that the prevalence of *Megamonas* was higher in children with both HIV and ID compared with HIV- and iron-sufficient nonanaemic counterparts.

Encouragingly, we found no indication of gut mucosal barrier disruption according to plasma I-FABP concentrations. Several studies have reported a loss of gut integrity in HIV+ individuals of varying age groups and support the chain of gastrointestinal events after HIV acquisition.<sup>12,35,36</sup> However, I-FABP is not consistently elevated in children and adults across studies. Our finding of no difference in I-FABP by HIV status is consistent with previous studies in African adults<sup>37</sup> and infants.<sup>38</sup>

Although increased faecal calprotectin was only suggestive of subclinical gut inflammation, the disparity between ID and iron-sufficient children was significant, and ID, but not HIV, was associated with an increased faecal calprotectin. Previous studies have observed a positive association between faecal calprotectin and dysbiosis in the context of gastrointestinal diseases.<sup>39,40</sup> In our study, both HIV and ID contributed to dysbiosis (discussed further), and therefore, we expected an increase in faecal calprotectin in both HIV+ and ID children. Possibly, the mild gut inflammation observed was not a consequence of ID but rather a contributor to the depleted iron stores in ID children by impairing dietary iron absorption.

The gut microbiota diversity indices suggest that bacterial richness and evenness were similar between the



**FIGURE 1** Relative abundance and diversity comparisons in virally suppressed HIV+ and HIV- children with sufficient iron stores (inflammation-unadjusted plasma ferritin >40 µg/L) and insufficient iron stores (inflammation-unadjusted plasma ferritin ≤40 µg/L). All children with sufficient iron stores were also nonanaemic (haemoglobin ≥115 g/L). (a) Relative abundance of faecal bacterial taxa at the genus level by HIV and iron status. Genera with low prevalence (detected in less than 20% of the samples) were excluded from the analysis. (b) Principal coordinate analysis of inter-individual differences by Bray-Curtis dissimilarity. (c) Alpha diversity using the Shannon index in different groups; no significant difference was observed (Kruskal-Wallis). (d) Within-group inter-individual Bray-Curtis distance (β-diversity); annotations above the box plots indicate significant difference between groups (Kruskal-Wallis followed by a post hoc Dunn's test with correction for multiple testing): \*\* $p < 0.01$  and \*\*\*\* $p < 0.0001$ .

HIV+ and HIV- children and independent of iron status. Previously, Abange et al. reported a lower Shannon index in Cameroonian HIV+ children and adolescents compared with HIV- counterparts,<sup>41</sup> whereas this was not the case in a Zimbabwean study by Flygel et al.<sup>42</sup> However, the latter group reported a decrease in α-diversity in HIV+ children based on other diversity indices. Although these two studies included children and adolescents on ART, a substantial proportion were not virally suppressed. The participants either initiated treatment during study enrolment, or their time spent on ART was not sufficient to achieve viral suppression. Furthermore, one of these studies implemented a higher threshold for viral suppression (1000 HIV RNA copies/ml)<sup>42</sup> than ours (50 HIV RNA copies/ml). Nowak et al. reported a positive correlation between gut microbial diversity and CD4+ T-cell count, which is restored when viral load is suppressed.<sup>43</sup> The comparable bacterial richness between HIV+ and HIV- children in

our study may be the result of successful viral suppression, as observed in previous studies.<sup>44,45</sup>

On the contrary, we detected a higher β-diversity (dissimilarity between participants) in HIV+ than HIV- children, consistent with several paediatric and adult studies.<sup>21,41-43</sup> Within both the HIV+ and HIV- groups, ID children displayed significantly higher β-diversity, suggesting that both HIV and ID can disrupt the microbiota and increase the variation within the composition. Thus, HIV and ID may additively contribute to dysbiosis.

Although *Prevotella* was previously associated with HIV,<sup>46,47</sup> our observation of a high relative abundance of *Prevotella* was not limited to HIV+ but observed in all four groups. Another recent study in young Capetonian children also reported a high relative abundance of *Prevotella*.<sup>48</sup> This was not surprising as *Prevotella* can be enriched in individuals from nonindustrialised countries whose diets are high in fibre and low in protein.<sup>49</sup>

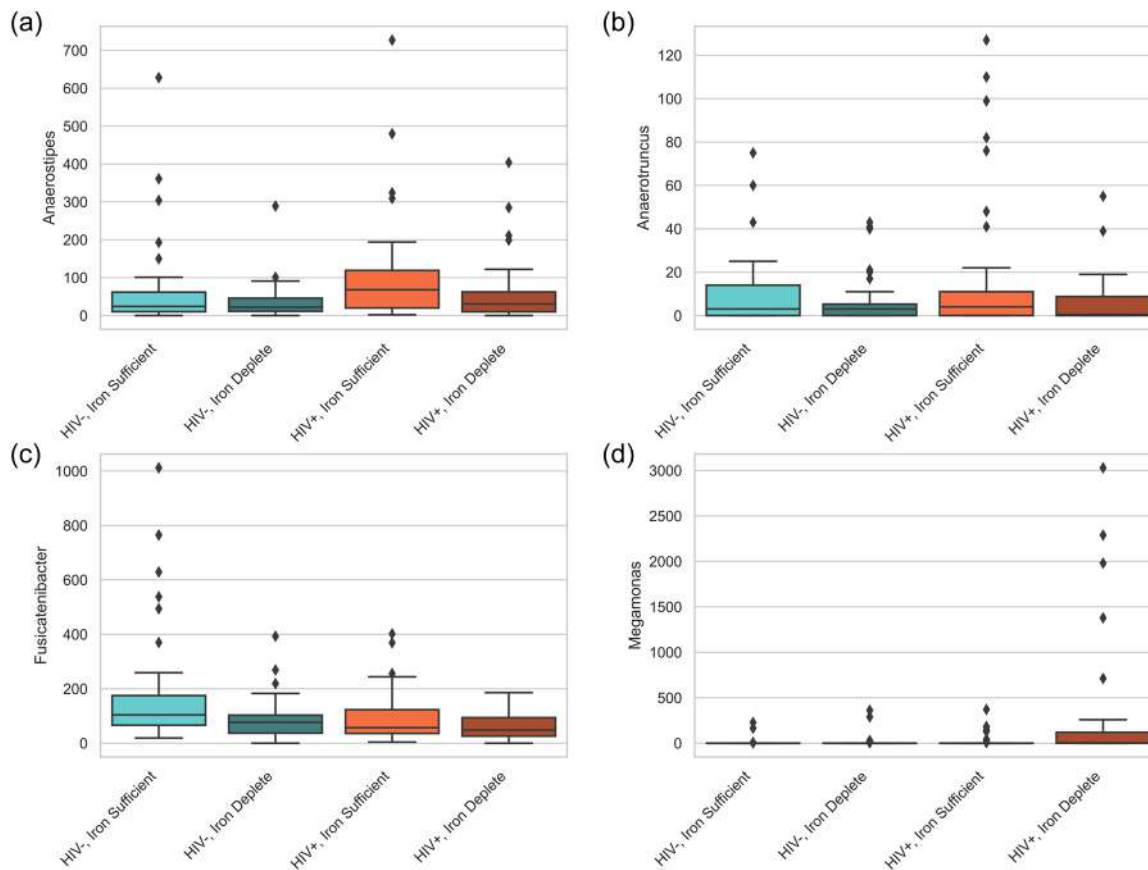
**TABLE 3** Genera with their relative abundance confidently linked with HIV status (without an effect of iron status) with their percentage change due to HIV status (mean and standard deviation from the probabilistic model) and the 94% highest density interval.

Genus	Relative abundance in children with no HIV or ID (per 10,000 reads)	Relative increase or decrease in abundance when HIV+ (%)	Highest density interval
<b>More abundant in HIV+</b>			
<i>Butyricimonas</i>	9.5	67	52–81
<i>Sutterella</i>	13.2	102	87–116
<i>Desulfomicrobium</i>	7.2	105	85–124
<i>Bacteroides</i>	309.7	112	109–115
<i>Alistipes</i>	42.7	130	121–139
<i>Clostridium_XIVb</i>	8.5	144	123–165
<i>Barnesiella</i>	14.3	150	134–167
<i>Desulfovibrio</i>	19.0	154	140–169
<i>Parabacteroides</i>	52.0	160	151–169
<i>Clostridium_XVIII</i>	16.2	180	163–197
<i>Bilophila</i>	4.5	202	168–237
<i>Phascolarctobacterium</i>	12.8	236	213–258
<i>Subdoligranulum</i>	1.5	253	189–324
<i>Odoribacter</i>	8.4	263	233–295
<i>Fusobacterium</i>	0.6	10,993	8108–14,058
<b>Less abundant in HIV+</b>			
<i>Turicibacter</i>	25.6	81	80–83
<i>Romboutsia</i>	37.3	71	69–73
<i>Intestinibacter</i>	18.2	63	60–67
<i>Clostridium_sensu_stricto</i>	58.0	57	55–59
<i>Terrisporobacter</i>	7.4	56	50–62
<i>Olsenella</i>	55.0	56	54–58
<i>Dialister</i>	208.2	55	54–56
<i>Bifidobacterium</i>	615.9	49	48–50
<i>Roseburia</i>	694.1	25	24–26
<i>Dorea</i>	264.2	17	16–19
<i>Faecalibacterium</i>	1437.8	16	16–17

The RDA revealed that ART-treated HIV and age were the only significant factors for explaining the variance in gut microbiota across the four groups. This was also confirmed by more significant differences in the relative abundances of bacterial genera across the four groups by HIV status than by iron status (27 versus 4 genera). HIV and ART are known modulators of the gut microbiota.<sup>19,50</sup> HIV-related variation in gut microbial profiles differ by viraemia<sup>51–53</sup> as well as by ART regimen.<sup>50,54</sup> Compared with recent HIV infection, an HIV-specific gut microbiota signature depleted of *Akkermansia*, *Anaerovibrio*, *Bifidobacterium* and *Clostridium* appears to develop over time, becoming evident on

long-term ART.<sup>55</sup> Of these genera and compared with HIV– counterparts, lower relative abundances of *Bifidobacteria* and *Clostridium* were noted in our sample of virally suppressed HIV+ children on ART. An interesting observation by HIV status was the steep increase in the relative abundance of *Fusobacterium* in the HIV+ children versus very low abundances in the HIV– children in our sample. *Fusobacterium* is a pathogenic bacterium with virulence factors that could trigger gut inflammation and disease.<sup>56</sup> An increase in the relative abundance of *Fusobacterium* was previously associated with suboptimal immune recovery and functioning despite ART.<sup>57</sup>





**FIGURE 2** Example of four genera's relative abundance for which the probabilistic models confidently found a shift in abundance based on HIV and/or iron status. (a, b) *Anaerostipes* and *Anaerotruncus* are associated with iron status, (c) *Fusicatenibacter* is associated with both HIV and iron status independently and (d) *Megamonas* is the only genus where an HIV  $\times$  iron status interaction effect was noted. The prevalence of *Megamonas* was higher in children with both HIV and ID versus HIV- and iron-sufficient nonanaemic counterparts.

In vitro and animal studies have highlighted the adverse effects of low colonic iron availability on butyrate-producing bacteria and short-chain fatty acid metabolism.<sup>8,9</sup> In our sample, the relative abundance of both *Anaerostipes* and *Anaerotruncus* was lower in ID children compared with iron-sufficient nonanaemic counterparts. *Anaerostipes* and *Anaerotruncus* are butyrate-producing probiotic bacteria strongly and positively correlated with Hb and serum ferritin in rats.<sup>58</sup> The short-chain fatty acid butyrate has anti-inflammatory effects and is beneficial to intestinal health.<sup>59</sup> Similar to our findings, a previous study among children with inflammatory bowel disease reported a lower abundance of butyrate-producing microbiota when faecal calprotectin was elevated.<sup>39</sup> Furthermore, our observation of a lower abundance of *Fusicatenibacter* in HIV+ as well as in ID children may also relate to gut inflammation, as a decrease in *Fusicatenibacter* has been associated with ulcerative colitis<sup>60</sup> and Crohn's diseases,<sup>61</sup> both chronic inflammatory diseases of the gut.

An HIV  $\times$  iron status interaction effect was observed only for the genus *Megamonas*, with a higher prevalence of *Megamonas* in children with both HIV and ID than

without HIV and ID. Although an increase in the relative abundance of *Megamonas* in ART-treated HIV+ adults has been reported,<sup>62</sup> literature associating *Megamonas* with ID is scarce. A study in women with gestational anaemia reported gut microbial enrichment of *Megamonas*.<sup>63</sup> In HIV+ adults either on ART or ART naive, *Megamonas* was correlated significantly with interleukin-6, a systemic inflammatory cytokine.<sup>64</sup> In our study, HIV was significantly associated with increases in both CRP and AGP concentrations. Although the levels of inflammation were low, if considered together with the iron status-associated increase in gut inflammation, and HIV and iron status-associated changes in gut microbiota composition, our findings support an interplay between HIV, iron status, gut health and systemic inflammation.

Our study had several strengths. We investigated the relationship of two factors, HIV and iron status, with gut health. By using probabilistic models adapted specifically for this study design, interpretable results for the specific research questions could be obtained. Furthermore, the partially pooled models allow maximum information to be used from each participant's sample, reducing uncertainty of the results. A limitation of this study is

that it was observational, and therefore, conclusions of causality or temporality cannot be drawn.

In conclusion, in 8- to 13-year-old virally suppressed HIV+ and HIV- children with or without ID, ID was associated with increased gut inflammation and changes in the relative abundance of specific microbiota. Moreover, in HIV+ children, ID had a cumulative effect that further shifted the gut microbiota to an unfavourable composition. Preventing ID in HIV+ children may benefit gut health, and supporting optimal iron status with context-appropriate interventions should be prioritised.

### AUTHOR CONTRIBUTIONS

Charlene Goosen designed the study and conducted the research. Charlene Goosen, Kashish Mallick and Jeannine Baumgartner analysed the data (other than the microbiota data). Sebastian Proost performed the microbiota analysis and visualisation. Raul Y. Tito processed 16S sequencing data. Charlene Goosen and Kashish Mallick prepared the original draft of the paper. Shaun L. Barnabas, Mark F. Cotton and Michael B. Zimmermann provided study resources. Jeroen Raes supervised the microbiota analysis and provided study resources. Renée Blaauw supervised the research study and provided study resources. All authors reviewed the paper and read and approved the final manuscript.

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### CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### ETHICAL APPROVAL

The study was approved by the health research ethics committees of ETH Zurich (EK 2018-N-40) and Stellenbosch University (M18/05/017 and S18/06/136).

### TRANSPARENCY DECLARATION

The lead authors affirm that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. The lead authors affirm that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained. The study cohort was from a trial registered at [clinicaltrials.gov](https://clinicaltrials.gov) as NCT03572010.

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### PEER REVIEW

The peer review history for this article is available at <https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/jhn.13171>.

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### SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# The lactation skill gaps of multidisciplinary paediatric healthcare professionals in the United Kingdom

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## Abstract

**Background:** Breastfeeding is an important public health priority and may be particularly beneficial for medically complex infants and children. However, childhood illness and disability are associated with increased challenges and lower breastfeeding rates. The Baby Friendly Initiative has been shown to increase initiation of breastfeeding and improve health professional skills although as yet the standards have not been adopted in paediatrics. Previous studies have found breastfeeding knowledge gaps among paediatric nurses, and a recent systematic review highlighted insufficient lactation support, discouragement by healthcare professionals and lack of resources. The aim of this survey of UK paediatric professionals was to establish their self-defined confidence and skills supporting breastfeeding.

**Methods:** An online survey was developed to explore associations between level of training and staff confidence and perceived skill, to establish whether there is evidence that more training and/or higher breastfeeding training credentials improve skill. In total, 409 professionals, including paediatric doctors at all grades, paediatric nurses and allied health professionals, were included in the analysis.

**Results:** This study identified specific skill gaps among professionals. Many healthcare professionals felt that different skills and specific training are required to support medically complex children. Several professionals noted that existing breastfeeding training focuses on establishing breastfeeding in healthy newborns rather than sick children in paediatrics. Participants were asked about 13 clinical competencies, and an aggregate skill score was calculated. Multiple univariate analysis of variance found that more extensive training and higher credentials are correlated with higher skill scores ( $p \leq 0.001$ ), whereas type of professional was not.

**Conclusions:** Despite this being a relatively motivated sample of healthcare professionals, the findings of this study suggest that breastfeeding skills are patchy and inconsistent, and particularly lacking when it comes to more complex clinical scenarios. This is significant, because it may mean that children who have more significant illness or medical complexity are disproportionately affected by gaps in knowledge and skill. Medically complex children encounter many barriers to optimal feeding – including absence of designated paediatric lactation staff, resources and support – and may have challenges such as low tone, higher calorie need and transitioning to the breast after ventilation or enteral feeding. Current skill gaps indicate that existing

training would be insufficient, and bespoke paediatric breastfeeding training based on identified clinical challenges is thus justified.

#### KEYWORDS

breastfeeding, clinical competencies, infant nutrition, paediatrics, public health

#### Key points

- Currently, there is no mandatory undergraduate breastfeeding training for paediatric healthcare professionals. Current optional training is weighted towards the initiation of breastfeeding in healthy term infants and supporting breast milk feeding in preterm infants, rather than sick infants and children admitted to paediatrics.
- Breastfeeding skill gaps in paediatric multidisciplinary healthcare professionals are widespread even in a relatively motivated sample.
- More extensive breastfeeding training is significantly associated with greater confidence and higher self-defined skills.
- Mandatory breastfeeding training for paediatric healthcare professionals should include not only basic breastfeeding principles but also additional training that is nuanced for the needs of the paediatric population.

## INTRODUCTION

Breastfeeding is known to provide optimal nutrition and immunological support to young children. There are many systems in place to facilitate and protect breastfeeding, including policies, training programmes and specialist practitioners employed. One of the most well-known is the UNICEF Baby Friendly Initiative (BFI) standards which aim to improve the standard of breastfeeding support through training, benchmarking and audit. When BFI is implemented, it has been found to increase rates of breastfeeding initiation.<sup>1</sup>

However, breastfeeding support and training available is typically weighted towards the initiation of breastfeeding in healthy newborns, as well as supporting the preterm population. Comparable support for older infants and children admitted to paediatric care is often missing despite the World Health Organisation recommendation to breastfeed children for up to 2 years and beyond,<sup>2</sup> with arguably a greater need for immunological protection in unwell children. For example, although BFI standards are implemented in many maternity and neonatal departments, there are no BFI-accredited children's hospitals or wards, and there is often a lack of investment in training, policy and staff expertise.<sup>3</sup>

It is not only that a lack of training and policy can have a broad impact upon supporting breastfeeding but also that within paediatrics, different breastfeeding challenges exist. Knowledge and skills acquired on a postnatal ward may not be sufficient to effectively support families where a child has medical complexity. Without designated specialist paediatric lactation support, the task of supporting breastfeeding is therefore likely to fall to clinical staff on the ward. However, several studies have found that breastfeeding training for physicians and nurses is inadequate,<sup>4-6</sup> lacks clarity

regarding the optimal educational approach,<sup>7</sup> and many healthcare professionals default to their own experiences of breastfeeding.<sup>8-10</sup> Moreover, training for staff such as those working in dietetics and speech and language therapy, who often support medically complex feeding, is patchy and may be formula industry-funded.<sup>11-16</sup>

Despite this situation, little research examines this issue and its impacts within paediatric settings. Research examining healthcare professionals' breastfeeding training and skill typically focuses on maternity and neonatal settings which misses the added complexity of the multidisciplinary nature of the paediatric environment. This lack of training and skill exacerbates the challenges for mothers breastfeeding their baby or child in paediatric care, increasing the risk of stopping breastfeeding at a crucial nutritional and emotional timepoint.<sup>17</sup> The aim of the current study was, therefore, to explore the current state of experience, training and self-defined clinical lactation skills of UK healthcare professionals in the paediatric setting, to identify potential skill gaps and make recommendations for further training.

## METHODS

### Study design

This study used a self-report online questionnaire consisting of closed and open questions to explore paediatric health professional attitudes, perceived skills and confidence level. Online surveys are an efficient way to reach a large number of participants across the United Kingdom, which was important because of the very limited data available from the United Kingdom, as well as lack of data from multidisciplinary paediatric settings.

## Participants

The survey was open from November 2020 to March 2021, to all UK health care professionals working in the paediatric setting. Inclusion criteria were:

- Participants aged 18 or over.
- Resident and working in the United Kingdom.
- Able to complete the questionnaire in English.
- Medical, nursing or allied health professionals currently working within paediatrics.
- Able to give informed consent.

Midwives, neonatal nurses and health visitors were excluded, even if they were currently working on a paediatric ward because these professionals may have different experiences and training if they come from a BFI-accredited unit.

Ethical approval was sought and granted by the Swansea University School of Health and Social Care Ethics Committee. All participants provided consent prior to completing the survey. Ethical considerations were made with respect to the principles for research on human subjects as outlined in the Declaration of Helsinki.<sup>18</sup>

## Measures

Participants completed an online survey consisting of five sections which was hosted online on Qualtrics UK. Sections included:

- Demographic and professional background of participants, including job role and length of service.
- How confident professionals feel about supporting breastfed infants and children.
- Undergraduate training and experience.
- Self-defined skills in supporting different aspects of lactation.
- Post-registration training and continuing professional development, including obtaining breastfeeding credentials such as peer supporter, breastfeeding counselor and International Board Certified Lactation Consultant (IBCLC).

Survey questions were developed based on identified challenges from a recent systematic review<sup>3</sup> to explore themes around perception of experience and confidence, as well as the extent to which professionals felt equipped by their training (Appendix A). Level of experience with 13 specific clinical lactation skills and correlations between training and breastfeeding expertise were also explored because they are likely to have an impact on breastfeeding exclusivity and duration among medically complex infants and children. Specific clinical lactation skills responses were summed up to give an overall skills score.

Responses to questions were collected using 5-point Likert scales (strongly agree to strongly disagree) with further options to add free text for some questions.

## Procedure

The study was advertised using social media posts via Facebook, Twitter and Instagram. Posts were shared on the pages of the authors who have combined followers of over 200,000 across Instagram, Facebook and Twitter with encouragement for interested viewers and organisations to share further. During the study period the advert was shared over 170 times across social media platforms. Brief details of the study background and inclusion criteria were included with a link to the survey participant information. If interested, professionals clicked on the link in the post, which contained details of the inclusion and exclusion criteria, along with further information about the study.

## Data analysis

Descriptive and inferential statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) 28.0. Frequencies and percentages of demographic data, including gender, ethnicity, profession and post-qualification years of experience as well as a number of other descriptors, were calculated. Correlations between variables were calculated using Spearman's and Pearson's correlation coefficients, as well as one-way analysis of variance (ANOVA) to establish whether there were statistically significant differences between groups. Given that a substantial number of professionals chose to include further details in the free text boxes, a thematic analysis was undertaken using a simple descriptive approach.<sup>19</sup> Themes were generated from the qualitative data relating to reasons for not undertaking further breastfeeding training. To develop the themes, the first author read and re-read the comments from professionals, assigning each comment with a code until no new codes were required to understand the data. Subthemes were developed from these codes, and themes were discussed between authors until agreement was reached.<sup>20</sup>

## Reliability and validity

Validity and reliability are important aspects to consider when designing a questionnaire for a survey.<sup>21</sup> There was no pre-existing validated tool fit for purpose, as previous surveys have used a pre- and posttest measurement after specific training,<sup>5</sup> or have measured very specific breastfeeding knowledge.<sup>22</sup> Neither of these tools was appropriate for the purpose

of the study. For this reason, questions around specific areas of clinical lactation challenge raised by parents in previous studies<sup>3</sup> were developed to gauge the level of skill and awareness. The questionnaire validity was improved by being reviewed by a nurse, IBCLC, paediatrician and two senior academics, and their feedback refined the questions. The questions were also reviewed by three parents of sick children to check that issues pertinent to their experience were covered. To enhance the validity of the qualitative data, themes from the participants were discussed between authors where there was ambiguity.

To test the reliability of the combined skills score in the survey, a Cronbach's  $\alpha$  was performed and found to have excellent internal consistency.

## RESULTS

### Participant demographics and location

A total of 496 professionals with unique IP addresses started the survey. Three participants were excluded because they were midwives or neonatal nurses. A further 84 people started the questionnaire but only completed the initial non-clinical questions and were therefore excluded. In total, 409 professionals completed all or most of the questionnaire. Those who answered at least 80% of the questions were included, but as responses to individual questions were not compulsory, the overall participant response rate for each question varies slightly.

Most of the participants were female (94.1%), and the most common profession represented was paediatric nursing (59.9%). The participants had a mix of ethnicities that was approximately representative of the UK population.<sup>23</sup> Approximately half (50.5%) of the sample had been qualified within their role for more than 10 years. Overall, there was a varied spread of geographical location and clinical environments, including theatre and recovery, outpatients, oncology and other specialist wards. The most common clinical area was the general paediatric medical or surgical ward (55.6%), but many respondents reported working in the high dependency unit or paediatric intensive care unit (21.3%). There were also three people who worked in a senior clinical role across all departments, or in an educational capacity.

### Training and qualifications

When asked about their undergraduate training, 66.5% ( $n = 246$ ) reported not having any training at all in breastfeeding, and a further 25.7% ( $n = 95$ ) had just 1–2 h of training. Only 3.2% ( $n = 12$ ) had a

whole day or more as part of their training. In terms of whether the health professionals felt that their undergraduate training had equipped them to be able to support families with breastfeeding in the paediatric setting, 71% ( $n = 264$ ) felt that they had not been equipped and only 15.3% ( $n = 57$ ) felt that their undergraduate breastfeeding training was sufficient.

### Breastfeeding credentials, skills and training

The professionals were asked about whether they had undertaken any additional training or had specific breastfeeding qualifications or credentials. Although breastfeeding training is not a core competency of health professionals in paediatrics, some choose to pursue additional training – either funded and facilitated by their healthcare institution or self-funded. A variety of breastfeeding training programmes are currently available, including short courses lasting between 1 and 3 days. Peer supporter training involves approximately 12 weeks of study with supervised practice, and opportunities thereafter to work in paid or voluntary roles in a variety of clinics, community and maternity settings. Breastfeeding counsellor (BFC) training usually lasts approximately 2 years and has a broader curriculum than that of a peer supporter. BFCs, like peer supporters, have a nonmedical, counselling focus. IBCLCs must meet the criteria of having provided 1000 verifiable hours of supervised breastfeeding support and completed 95 h of lactation specific training before passing an exam.

Some of the professionals reported having completed training lasting 1–3 days. Several professionals (11.49%,  $n = 47$ ) had accessed peer supporter training. Fewer professionals had undertaken BFC training (4.9%,  $n = 20$ ), and even less had accessed IBCLC preparation courses or other extensive breastfeeding training providing 50–90+ h of tuition (1.9%,  $n = 8$ ). Because of the small numbers of professionals who had more extensive training, particularly at BFC and IBCLC levels, training was coded as 'extensive' at peer supporter level and up. Professionals who had attended between 1 and 3 days' training were considered to have had 'some' training, and those who had not attended any were coded as 'none' (Table 1).

As Table 1 shows, most of the sample (81.8%,  $n = 294$ ) felt they would benefit from further training in breastfeeding. Despite the high numbers of professionals agreeing that they would benefit from further training, 69% ( $n = 245$ ) had not asked for it. A free text box (see Table 2) enabled professionals to provide reasons for not asking for training. In total, 165 professionals left comments, which were coded into 16 unique themes, showing the complexity of the issue. Many did not ask for training because it was not perceived to be appropriate or felt to be a priority, with many deferring to their own experience.



TABLE 1 Postqualification training and breastfeeding credentials.

Question	Variable	n	%
Do you have any breastfeeding credentials?	IBCLC	8	1.9
	BFC	20	4.9
	PS	47	11.49
	None	334	81.6
Have you attended any breastfeeding training?	Extensive (PS and above)	75	18.3
	Some	71	17.3
	None	263	64.3
Have you been provided with breastfeeding training?	It is mandatory	59	16.6
	It is offered, but not mandatory	114	32.1
	It is not provided	165	46.5
	Not sure	17	4.8
I feel I need or could benefit from breastfeeding training	Strongly agree/ Agree	294	81.8
	Strongly disagree/ Disagree	13	3.3
Have you asked for breastfeeding training from your manager?	Asked, and received	71	20.2
	Asked, but refused	38	10.8
	Not asked	243	69.0
In paediatrics, you need different or additional skills, compared with healthy children	Strongly agree/ Agree	331	93.3
	Strongly disagree/ Disagree	1	0.3

Abbreviations: BFC, breastfeeding counsellor; IBCLC, International Board Certified Lactation Consultant; PS, peer supporter.

## Confidence and experience in supporting breastfeeding

Participants were asked to rate how experienced and confident they felt supporting breastfeeding. Response options were via a 5-point Likert scale (strongly agree to strongly disagree). In terms of how experienced the professionals felt they were at supporting parents to breastfeed, 53.8% ( $n = 205$ ) agreed that they felt experienced with 25.2% ( $n = 96$ ) feeling that they lacked sufficient experience. Likewise, when asked 'On an average shift, I feel confident about being able to answer any questions about breastfeeding?' 53.1% ( $n = 198$ ) agreed and 23.6% ( $n = 88$ ) disagreed. One-way ANOVAs found that there was no statistically significant difference between professional groups and how confident they felt ( $F(4, 366) = 1.159$ ,  $p = 0.329$ ) or between professional groups and how experienced they felt ( $F(4, 375) = 1.661$ ,  $p = 0.158$ ).

A one-way ANOVA then explored whether different professions were more or less likely to believe that breastfeeding was not part of their job description. In this sample, there was no statistically significant difference between professional groups in the belief that supporting breastfeeding is part of their role ( $F(4, 349) = 474$ ,  $p = 0.755$ ).

Questions also explored how experienced professionals felt they were in supporting breastfeeding, whether they had any additional responsibility for infant feeding on their ward or unit and the source of their knowledge (Table 3).

When asked about the source of their breastfeeding knowledge, some of the professionals (12.6%,  $n = 62$ ) had personally funded additional training, whereas others reported that their training came from their personal experience (44.4%,  $n = 219$ ), another colleague on the ward (27.8%,  $n = 137$ ), NHS funded training (25.4%,  $n = 125$ ) and websites or books (25.8%,  $n = 127$ ). About 12.4% ( $n = 61$ ) reported that their undergraduate training was the source of their knowledge, and 5.9% ( $n = 29$ ) felt they didn't have any specific knowledge.

## The relationship between attitudes to breastfeeding, training and confidence

It is feasible that professionals who value breastfeeding seek out more training and feel more confident in supporting families. Pearson's correlations were used to explore these relationships, finding a significant positive correlation between a belief that breastfeeding is important and breastfeeding support confidence ( $r(371) = 227$ ,  $p < 0.001$ ) and similarly a significant positive correlation was found between the belief that breastfeeding is important and desire for more training ( $r(354) = 209$ ,  $p < 0.001$ ). Additionally, those who believed that supporting breastfeeding goals was part of the job were significantly more likely to also have a higher desire for more training ( $r(354) = 31$ ,  $p \leq 0.001$ ), and a higher level of confidence in supporting breastfeeding ( $r(371) = 33$ ,  $p \leq 0.001$ ).

In terms of training received (which was grouped by 'none', 'some' [1–3 day training] and extensive [peer supporter, BFC and IBCLC]), a Spearman correlation coefficient calculation found a significantly positive correlation between a belief that supporting breastfeeding is part of the job and more extensive training in breastfeeding ( $r(355) = 115$ ,  $p = 0.03$ ) suggesting that those most committed to supporting breastfeeding on the ward also demonstrate this commitment through accessing further training.

In terms of perceived health professional confidence, it could be expected that greater experience and training would lead to greater levels of confidence. Spearman's correlation found a significant positive correlation between confidence and higher breastfeeding credentials ( $r(373) = 322$ ,  $p < 0.001$ ). Those who felt more confident also had a higher level of experience, measured using participant self-report with Likert scales



TABLE 2 Reported reasons for not asking for breastfeeding training.

Reasons	Examples
1. Lacking confidence to ask	<p>‘My manager isn’t approachable’ (Paediatric nurse)</p> <p>‘Know they wouldn’t think it was important enough’ (Paediatrician)</p>
2. Unaware	<p>‘Don’t see it [breastfeeding] often on PICU so rely on my own experiences, and didn’t know courses exist’ (Paediatric nurse)</p> <p>‘There is no training for this in paediatrics’ (Nursery nurse)</p> <p>‘Didn’t know it was available’ (Paediatrician)</p>
3. Not invested	<p>‘It does not particularly interest me’ (Paediatric nurse)</p> <p>‘One expects that the training one is given is already appropriate and complete. I don’t think trainees should be expected to know what the gaps in their training are – this should come from deaneries/trainers/supervisors’ (Paediatrician)</p>
4. Limited exposure to breastfeeding	<p>‘Very rare to have a breastfed baby on the ward’ (Paediatric nurse)</p>
5. Hostility	<p>‘Because it is not my job! Would rather not have the breastfeeding police infiltrating paediatrics!’ (Paediatrician)</p> <p>‘Current unit not pro breastfeeding’ (Paediatrician)</p>
6. Not felt to be necessary	<p>‘Most children are established with breastfeeding already or are receiving other methods of feeding (i.e., enteral)’ (Paediatric nurse)</p> <p>‘Always “got by” without it’ (Paediatric nurse)</p>
7. Already feel skilled	<p>‘Not needed as previous role was Health Visitor’ (Paediatric nurse)</p>
8. Cessation of training due to COVID-19 pandemic	<p>‘Asked and was due to attend but it was cancelled as it was during lockdown. It has not been rescheduled’ (allied health professional [AHP])</p>
9. Training isn’t helpful	<p>‘The course we get put on isn’t helpful and my own knowledge from teaching myself and feeding my babies is more than the course gives’ (Adult nurse working in paediatrics)</p>
10. Being newly qualified	<p>‘Only qualified for year and a half, unaware of what is extra training’ (Paediatric nurse)</p>
11. Delegate to midwives/neonatal team	<p>‘I feel that if I ever have a problem that I need sorting with breastfeeding, I contact NICU and the midwives there and they can give advice and come help the mum personally. So, there is expertise available, it just may not be me’ (Paediatric nurse)</p>
12. Lack of time, or the training would be undertaken on annual leave	<p>‘Breastfeeding training is available but in your own time and very limited availability’ (Paediatric nurse)</p> <p>‘Lack of time/opportunity’ (Paediatrician)</p>
13. Existing training focuses on establishing feeding in healthy newborns and sick neonates	<p>‘Some is provided via neonatal training, but breastfeeding seems relatively forgotten about in the paediatric setting’ (Paediatrician)</p> <p>‘Only basic training available (1/2 day)’ (AHP)</p>
14. Not felt to be applicable to their role	<p>‘Not obligated for role’ (Paediatrician)</p> <p>‘Not applicable to job role’ (AHP)</p>
15. Other clinical priorities	<p>‘Often we don’t have time, and more pathological conditions take precedent’ (Paediatrician)</p>
16. Rely on personal experience of breastfeeding to get through any questions that arise	<p>‘Personal experience of breastfeeding difficulties I feel I have a good knowledge. Breastfeeding training (in neonates) roughly every 6 m focuses on the benefits of BF rather than how to overcome any of the difficulties’ (Paediatrician)</p> <p>‘I have learnt a lot through my own breastfeeding journeys’ (Paediatrician)</p>

Question	Response option	<i>n</i>	%
Do you have any additional responsibility for infant feeding on your ward/department?	Yes	64	17.9
	No	293	82.1
Where does your experience come from?	My undergraduate training	61	12.4
	Additional courses provided by my NHS employer	125	25.4
	Private courses or training I have funded myself	62	12.6
	My personal breastfeeding experience	219	44.4
	A colleague on the ward	137	27.8
	Websites/books	127	25.8
	I don't feel like I have a specific information	29	5.9
Is there someone who has been identified as having additional expertise on the ward?	Yes	229	64.5
	No	84	23.7
	Not sure	42	11.8

TABLE 3 Participant responsibility for and experience of supporting breastfeeding.

( $r(371) = 76$ ,  $p < 0.001$ ). Those who had greater confidence were also significantly more likely to recognise that differences in skills could be needed to support a paediatric population ( $r(353) = 16$ ,  $p = 0.002$ ) and that different or additional tools and skills are required to adequately support breastfeeding, compared to supporting healthy children ( $r(371) = 16$ ,  $p \leq 0.002$ ).

Awareness of the need for training was also linked to experience. Pearson's correlations found a significant relationship between professionals' self-identified need for training and whether they felt there was enough support on their unit ( $r(343) = -0.262$ ,  $p \leq 0.001$ ), suggesting that those who feel they need more training are more likely to feel that families are not well supported – possibly due to increased awareness of the information and support *not* being provided on their ward or unit.

### Specific lactation support skills

Based on many of the areas of challenge elucidated from previous research, professionals were asked if they had any experience supporting 13 specific breastfeeding skill areas (response options: yes, lots, yes, a little and no). Table 4 shows the proportion of participants who agreed that they had different levels of experience supporting specific breastfeeding challenges.

Respondents were more likely to identify having lots of experience in simple aspects of breastfeeding support such as supporting parents to express milk and providing encouragement. The skills that professionals felt they had generally less experience with

included identifying poor milk transfer through a feed assessment and supporting hypotonic infants. Less than 9% of respondents ( $n = 348$ ) had lots of experience supporting infants with orofacial anomalies and relaxation.

### Aggregate skill score

As there were numerous breastfeeding skills rated by participants, an overall skill score was calculated by combining responses for each individual skill. Responses were scored as 'Yes, lots' [3], 'Yes, a little' [2] and 'No' [1] giving a potential score from 13 to 39. The range of the scores was 13–39, with a median score of 23, and a mean score of 24.544 (SD  $\pm 6.622$ ). To test the internal consistency of these items as a combined scale, Cronbach's  $\alpha$  was computed ( $\alpha = 0.916$ ) demonstrating excellent internal consistency across these items.

Next the relationships between perceived level of skill and experience and training and other factors that might have impacted breastfeeding skills were examined. Table 5 shows the differences in skill score across different aspects of experience, responsibility and training. Several tests were used to explore skill differences by different training aspects. Spearman's correlations found that skill scores were significantly correlated with post-qualification years of experience ( $r(408) = 125$ ,  $p = 0.016$ ) and extent of training ('Extensive', 'Some' and 'None') ( $r(368) = 423$ ,  $p \leq 0.001$ ). Pearson's correlation found a significant positive correlation between skill level and perception of having greater experience in supporting breastfeeding ( $r(386) = 676$ ,  $p \leq 0.001$ ).

**TABLE 4** Participants' perceptions of own breastfeeding clinical skills.

Specific breastfeeding skills	Lots		Some		None	
	N	%	N	%	N	%
Providing encouragement to breastfeed	193	50.8	152	40.0	35	9.2
Supporting mothers to express milk	152	40.0	162	42.6	66	17.4
Able to identify adequate milk intake	123	32.5	160	42.2	96	25.3
Able to provide information about the benefits of non-nutritive sucking	116	30.4	176	46.2	89	23.4
Helping mothers to protect or increase their milk supply	111	29.1	170	44.6	100	26.2
Improving latch to reduce nipple pain	96	25.2	170	44.6	115	30.2
Supporting infants with high caloric need	78	20.4	145	38.0	159	41.6
Helping mothers to restart breastfeeding after tube feeding	75	19.8	158	41.7	146	38.5
Supporting common breastfeeding challenges, such as mastitis	70	18.4	150	39.4	161	42.3
Experience with hypotonic/sleepy infants	68	17.9	151	39.8	160	42.2
Identifying poor milk transfer through a feed assessment	60	15.8	145	38.2	175	46.1
Experience supporting infants with orofacial anomalies	34	8.9	121	31.7	227	59.4
Supporting relactation (restarting breastfeeding after a gap)	33	8.7	91	25.1	257	67.5

Significant differences in skill score were also found between those who had additional responsibility and those with no additional responsibility for infant feeding. A one-way ANOVA test showed that those with additional responsibility had higher self-assessed skills ( $F(1, 344) = [59.870], p \leq 0.001$ ). However, there was no statistically significant difference in skill scores by profession ( $F(4, 362) = [2.226], p = .066$ ), or amount of undergraduate training ( $F(4, 356) = [1.621], p = .168$ ).

## DISCUSSION

This study, which explored the perceived skills, training and experience of professionals working in paediatric wards and units in the United Kingdom, recruited more than 400 healthcare professionals, including paediatric nurses, doctors at all grades and allied health professionals. The relatively high levels of positivity towards breastfeeding were anticipated given that this was a self-selecting sample exploring breastfeeding. Nevertheless, despite this being a motivated sample, there were many gaps in knowledge, with very few being confident and experienced to support a full range of clinical lactation challenges. Some of the skills could be classified as specialist – for example, supporting the return to direct breastfeeding after tube feeding. It could therefore be argued that not all staff would be expected to be competent in all skills. However, the sample included 133 professionals who worked in an intensive care environment and therefore could reasonably be expected

to have some exposure to these scenarios. Additionally, more than half the sample reported that they would feel confident to answer *any* questions that arose during their work with breastfeeding families, yet this was not borne out when they were subsequently asked about specific clinical skills. This may suggest that these clinical scenarios had not occurred to them prior to being prompted, or that they were unaware of their own gaps in knowledge.

Worryingly, the gaps in skill were not limited to more complex clinical scenarios such as relactation, but also to breastfeeding fundamentals. For example, only about 15% of the sample had lots of experience identifying poor milk transfer through undertaking a feeding assessment – which is far lower than might have been expected for a sample that self-identified as being relatively experienced. Given the likely overrepresentation of more informed and skilled professionals, the implication is that a more representative sample is likely to have greater skill and knowledge gaps as well as more negative attitudes.

### Attitudes, confidence and experience with breastfeeding support

In this study, more than half the sample felt they were experienced with supporting breastfeeding, and a similar number felt confident about addressing most questions that arose on their shift. Many of the professionals reported that their experience comes from their own personal breastfeeding journey. This was reflected in

TABLE 5 Comparisons of skill scores by different indicators of experience and responsibility in infant feeding support.

Question	Variable	N (368)	%	Mean skill score $\pm$ SD 24.543 $\pm$ 6.622	Significance
Skill by credential	IBCLC	8	2.17	36.125 $\pm$ 3.136	$F(3, 364) = [24.730]$ , $p \leq 0.001$
	BFC	19	5.16	30.842 $\pm$ 5.510	
	PS	46	12.5	27.717 $\pm$ 5.698	
	None	295	80.16	23.328 $\pm$ 6.198	
Skill by level of training	Extensive	65	17.66	29.461 $\pm$ 5.929	$r(368) = 423$ , $p \leq 0.001$
	Some	77	20.92	26.597 $\pm$ 6.341	
	None	226	61.41	22.429 $\pm$ 6.622	
Skill by profession	Paediatric nurse	224	60.86	24.821 $\pm$ 6.508	$F(4, 362) = [2.226]$ , $p = 0.066$
	Health Care Assistant (HCA)	9	2.44	22.111 $\pm$ 7.896	
	Paediatrician	92	25.0	23.217 $\pm$ 5.217	
	Allied health professional (AHP)	39	10.59	26.435 $\pm$ 8.567	
Skill by number of years post qualification	<2 years	23	6.25	23.826 $\pm$ 5.449	$r(408) = 125$ , $p = 0.016$
	2–5 years	59	16.03	23.118 $\pm$ 6.028	
	5–10 years	98	26.63	23.806 $\pm$ 6.223	
	10–15 years	79	21.46	24.683 $\pm$ 6.115	
	15+ years	108	29.34	24.504 $\pm$ 6.588	
Skill by extent of agreement of having lots of experience	Strongly agree	63	17.11	32.158 $\pm$ 5.562	$r(386) = 676$ , $p \leq 0.001$
	Agree	137	37.22	26.379 $\pm$ 5.009	
	Neutral	73	19.83	21.739 $\pm$ 4.790	
	Disagree	77	20.92	19.389 $\pm$ 4.069	
	Strongly disagree	17	4.61	17.058 $\pm$ 6.630	
Skill by additional infant feeding responsibility	Additional responsibility	63	17.11	30.031 $\pm$ 5.710	$F(1, 344) = [59.870]$ , $p \leq 0.001$
	No additional responsibility	283	76.90	23.413 $\pm$ 6.230	

Abbreviations: BFC, breastfeeding counsellor; IBCLC, International Board Certified Lactation Consultant; PS, peer supporter.

many of the comments left in the free text boxes, with several professionals stating that they did not feel the need for training as they had their own personal experience. This has previously been highlighted by several other studies exploring training and attitudes of general practitioners,<sup>24,25</sup> obstetricians and gynaecologists,<sup>26</sup> medical students<sup>27</sup> and paediatricians.<sup>8,28</sup> However, many of these studies have also found that knowledge is lacking, clinicians do not feel confident and practice may not be evidence-based.<sup>9</sup> This is problematic because parents are more likely to receive conflicting or inaccurate information which may make achieving their breastfeeding goals harder. Biases and negative attitudes can be hard to change, and studies in other clinical settings have found that personal experience of breastfeeding not only can impact the care

provided but also highlight the differences between theory and practice.<sup>6,10</sup> In this study, there was no significant difference between groups of professionals and the belief that breastfeeding was part of their job, so despite the speculation by some of the professionals in the sample, no single professional group appeared to believe that supporting breastfeeding was someone else's job.

Notably, there were some hostile comments and some professionals who felt strongly that breastfeeding support was *not* part of their job, or that it was not important for children. Although these attitudes were relatively rare in this sample, they are concerning given that this study is likely to have an overrepresentation of breastfeeding advocates. It is therefore unknown how prevalent these hostile attitudes are more broadly in UK

paediatric settings. Negative attitudes are potentially damaging to families, given that hospitalisation can significantly impact breastfeeding.<sup>29,30</sup> One study found that nurses' attitudes towards breastfeeding were strongly influenced by whether they themselves were breastfed, and many nursing students felt that encouraging mothers to breastfeed is synonymous with pressurising them.<sup>31</sup>

Some of the participants in this study demonstrated ambivalence – with 4% of the sample selecting the 'neither agree nor disagree' option for the questions relating to the importance of breastfeeding. Ambivalence has previously been found to discourage breastfeeding.<sup>32</sup> Active support and encouragement are known to promote breastfeeding, especially when this comes from a health professional<sup>33,34</sup> and thus the attitude of not appearing to have an opinion on infant feeding may have a detrimental impact on the maintenance of breastfeeding during illness.

### Undergraduate training

It is important to consider undergraduate training as the first potential exposure to information that may shape practice. Very few respondents had received at least a whole day of training on breastfeeding, with the majority expected to learn on the job. Yang et al.<sup>35</sup> found that a common issue is that most health professional students learn from supervising colleagues in the clinical setting, which introduces a considerable degree of variability and bias. A minority of respondents felt that their undergraduate training had adequately prepared them for supporting families on the ward. The sense that undergraduate training is insufficient to prepare clinicians for the practicalities of supporting breastfeeding was echoed in a study by Brzezinski et al.,<sup>36</sup> which similarly found many skill gaps and lack of confidence among paediatric nurse practitioners, despite them having a positive attitude towards breastfeeding.

The low rates of provision of breastfeeding training to undergraduate healthcare professional students are unsurprising given the absence of oral infant feeding on any clinical competency but are nevertheless concerning and are likely to be contributing to the widespread lack of confidence among practitioners.<sup>8,37–39</sup>

### Credentials, skills and postqualification training

In terms of postqualification training, only a minority had extensive breastfeeding training, and the majority had not received *any* breastfeeding training. Breastfeeding credentials provided by different training organisations are varied, with different curricula and inconsistent assessment or credentialing procedures.<sup>40</sup> Training may also be provided by nonclinical BFCs and IBCLCs, but there are no studies that have explored the effectiveness of this training by lay

professionals, or indeed joint training.<sup>41</sup> The skill sets of clinical and nonclinical lactation supporters are likely to be different, even though they may attend similar lactation training. This is because clinicians' breastfeeding knowledge and how to apply or adapt this knowledge to sick children is likely to be augmented by their clinical training and experience. It is therefore important to acknowledge that although many nonclinical lactation professionals provide effective support to lactating mothers of healthy children, it is unclear where *their* skill gaps are when working with medically complex children.

Only 15% of the participants in this study were dual-qualified healthcare and lactation professionals, and the ones who were had consistently higher levels of skill. There is a paucity of research on these dual-qualified professionals, but one study found that compared with visiting a paediatrician, parents had more confidence and trust when receiving support from a dual qualified paediatrician and IBCLC.<sup>42</sup> Other areas in the United Kingdom have established specialist clinics within health visiting and midwifery services that are staffed by dual-qualified health professionals and IBCLCs.<sup>43–46</sup> However, extensive breastfeeding training requires significant investment which is not always realistic alongside clinical work. Having 1–3 days of training did not increase skill scores as significantly; however, this is likely to be a much more realistic time commitment alongside busy NHS roles.

When asked about what would help professionals support parents better, more people selected specific breastfeeding training relating to sick children than any other intervention. Interestingly, professionals with higher skill scores were more likely to agree that they need or would benefit from training. Indeed, this awareness of the need for training has previously been found among studies of junior doctors<sup>37</sup> and medical students.<sup>38</sup> Despite the clear perception that training would be beneficial, most of the respondents had not asked their manager for training. When asked why, the responses included the training not being easy to access, pitched at an inappropriate level, not fit for purpose or hard to prioritise amidst other competing clinical needs. A small study in a large children's hospital found that current training focused on healthy infants, rather than supporting breastfeeding in complex cases.<sup>8</sup> Another study found that there is a lack of practical skills-based training provided to healthcare professionals.<sup>39</sup> This issue was raised numerous times by the participants of this study, with many pointing out that their knowledge of breastfeeding from their own experience of overcoming challenges had provided more information than that which would be gained from currently available training.

### Breastfeeding clinical skills

Despite relatively high numbers of professionals having additional training and credentials, there were



many skill gaps. In this study, *any* training was associated with having skill scores above the mean, and participants were able to select 'some' experience in terms of their skill, which does not necessarily equate to full competence.

Many studies have previously found that breastfeeding training improves clinical skills and knowledge of healthcare professionals.<sup>5,9,22,47-49</sup> One randomised controlled trial found that a 14-min educational DVD significantly increased professionals' skills in positioning and attachment and hand expressing.<sup>50</sup> To try to reduce the levels of breastfeeding modification after hospitalisation for bronchiolitis, a programme of training, as well as investment in more breast pumps and better signage and health promotion posters, was implemented. The researchers in the study found that following this programme, only 20% of mothers had unwanted breastfeeding modification after discharge from hospital, compared with 50% before the training programme.<sup>29,51</sup>

More training has been clearly shown to increase skills in a general sense, but no study has so far explored the impact of different levels of training on skills. In this study, different levels of training had a clear impact on subsequent skill scores. There was more consistency and breadth of skill with higher credentials. The skill scores were higher in the IBCLC group compared to the other groups, yet this was not statistically significant and because the number of IBCLCs in this sample was small, their scores were combined with those of the BFCs and peer supporters.

No significant correlations exist between level of skill and profession, although some groups such as allied health professionals may be too small to see differences. Although caution is required as this may not be representative of the broader situation on paediatric wards, it suggests that multi-disciplinary learning may be a valid option, as there may not necessarily be a professional group that stands out as being significantly more or less clinically competent with breastfeeding support.

The difference between the professionals who felt they were the most experienced and those who felt they were the least experienced represents a significant clinical skill shortfall which has the potential to impact the care a breastfeeding family receives on a very practical level. These skill gaps additionally are likely to impact children with more serious illness disproportionately because the clinical skill scores were generally lower for more complex lactation challenges. The feeding needs of critically ill children are under-researched, and this is also evident within this study. It is particularly notable that breastfeeding competence with critically sick children is lacking because challenges such as feeding intolerance is known to be a significant problem,<sup>52-54</sup> as well as both fluid overload<sup>55</sup> and undernutrition,<sup>56</sup> and human milk may be easier to digest.<sup>57,58</sup>

## LIMITATIONS

There were several limitations of this study. Firstly, this study recruited healthcare professionals via an online advert for practical access reasons during the COVID pandemic, and also to reach a large sample of professionals. Online surveys are a popular and cost-effective way of reaching a large sample within a population of interest, partly because technology has become more accessible but also because they are convenient to complete at a time that suits the respondent – which may increase the response rate.<sup>59</sup> The disadvantages include the lack of opportunity for a researcher to clarify questions, survey fraud and the bias towards people who can access the Internet.<sup>60</sup> Selection bias can be mitigated by predicating it and understanding that those most invested in making a phenomenon better are more likely to complete a survey relating to the phenomenon.<sup>61</sup> Predicting this selection bias influenced the choice of questions to increase the generalizability of the results. Nevertheless, despite the fact that this study is likely to have recruited an overrepresentation of breastfeeding advocates, level of skill was still generally low, which highlights a major gap within paediatrics.

Another limitation is the lack of quantification of level of experience with clinical skills. Asking professionals whether they had 'some' or 'lots' of experience was a deliberate use of language chosen to avoid professionals being put off answering through feeling embarrassed or unsure. It is also impossible to accurately quantify these skills without a practical skills test or in-depth individual audit. Thus, the use of the words 'some', and 'lots' was a pragmatic solution. Although these words are subjective, they are also non-threatening, and the completion rate of these questions was high. The usefulness of this question was increased by further questions that have, in combination, suggested that participants were generally honest about their abilities. However, future studies should attempt to quantify this with more objective accuracy.

Finally, not all the data are complete, due to some professionals exiting the survey before completing it or omitting questions. One of the problems with online research is that the researcher is unable to prompt the participant, ask for clarification or encourage them,<sup>62,63</sup> but on balance, with controversial topics, online research may enhance the acceptability of the questions because of anonymity.

## CONCLUSION

In terms of what is important to families, we know that they need timely, accurate information<sup>64</sup> and individualised support based on their needs.<sup>49</sup> The findings of this study suggest that breastfeeding skills are patchy and inconsistent, and particularly lacking when it comes to

more complex clinical scenarios. The potential skill gaps may be explained by the fact that in general, most health professionals defer to their personal experience when trying to answer questions about breastfeeding challenges, and the currently available training is focused on healthy term infants, rather than populations with more complex needs. Although professionals are obliged to take responsibility for their own ongoing development and learning needs, in reality, although breastfeeding training is not mandatory, it is likely that only those who are already invested will choose to attend further training. Mandatory infant feeding training is likely to be the only way to ensure that all those who are involved with sick infants and children have a minimum standard of breastfeeding awareness and training. This training should not only cover basic principles of infant feeding but also equip professionals to refer families to specialist resources if these are needed. In addition, paediatric infant feeding leads should be appointed, and these individuals should receive additional training in some of the more unique and specialised lactation skills identified as skill deficits in this study.

Despite this being a relatively invested sample, there was evidence of some antagonism towards breastfeeding, and many professionals not only did not know how to support families with lactation challenges but also did not know to whom they could refer. Skill deficits identified in this study indicate that existing training is insufficient, and bespoke paediatric breastfeeding training based on the identified clinical challenges is justified.

#### AUTHOR CONTRIBUTIONS

Lyndsey Hookway and Amy Brown were responsible for study conception. Lyndsey Hookway was responsible for data collection, analysis and draft manuscript completion. Amy Brown was involved in supervision of statistical analysis. Lyndsey Hookway and Amy Brown were both involved with critical revisions.

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#### CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

#### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

#### TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with STROBE. The lead author affirms that no important

aspects of the study have been omitted and that any discrepancies from the study have been explained.

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#### PEER REVIEW

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## APPENDIX A: HEALTH CARE PROFESSIONAL SURVEY QUESTIONS

### Section 1: About your clinical experience and where you work

#### 1.1 What is your ethnicity?

White/White British	White/White Irish	Gypsy/Traveller	Asian or Asian British: Bangladeshi	Asian or Asian British Indian	Asian or Asian British: Pakistani
Asian or Asian British: Chinese	Asian or Asian British: Other	Black or Black British	Mixed or Multiple	Other	Prefer not to say

#### 1.2 What is your gender?

- Female
- Male
- Trans \*male
- Trans \*female
- Gender non-binary
- Self-defined (please state)
- Prefer not to say

#### 1.3 What is your profession? (Choose one)

- Paediatric nurse
- Health care assistant working in paediatrics
- Paediatrician (consultant)
- Paediatrician (clinical fellow)
- Paediatrician (ST 1-6)
- Physiotherapist
- Occupational therapist
- Speech and language therapist
- Dietician
- Other

#### 1.4 How long have you been qualified? (Choose one)

- Less than 2 years
- 2–5 years
- 5–10 years
- 10–15 years

- 15+ years

#### 1.5 Do you work in a specialist (tertiary) paediatric referral centre, or a local hospital? (Choose one)

- Specialist centre
- Local hospital

#### 1.6 Which region best describes where you work?

- England – North
- England – South
- England – East
- England – South West
- England – Central
- England – London
- Wales
- Scotland
- Northern Ireland
- Ireland

#### 1.6 Within your hospital, what kind of environment(s) do you work in? (Allow more than one)

- General paediatric medical/surgical ward
- Ambulatory care/rapid assessment unit
- Emergency department
- PICU
- Cardiac intensive care unit
- Children's outpatients



- Theatre/recovery
- Other

1.7 Do you regularly care for infants and children under the age of 2 (Choose one)

- Every shift
- Nearly every shift
- Hardly ever
- Not at all

### Section 2: How you feel about supporting families of breastfed infants and children

2.1 How much would you agree with this statement: "I have a lot of experience supporting breastfeeding"? (Choose one)

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

2.2 Where does your breastfeeding information largely come from? (Allow more than one)

- My undergraduate training
- Additional courses provided by my NHS employer
- Private courses or training I have funded myself
- My personal breastfeeding experience
- A colleague on the ward
- Websites
- I don't feel like I have any specific information

2.3 Do you have any experience supporting families with any of the following issues: (Allow more than one)

- Providing encouragement to breastfeed
- Positioning, improving latch to help with nipple pain
- Identifying poor milk transfer
- Identifying adequate milk intake
- Supporting common breastfeeding parental challenges, such as mastitis, blocked ducts
- Supporting parents to express their milk
- Helping parents who need to be able to protect or increase their milk supply
- Re-starting breastfeeding, or inducing lactation
- Supporting infants with higher caloric need
- Supporting infants with low tone or sleepiness
- Supporting infants with anatomical challenges such as oro-facial anomalies
- Supporting infants to return to breastfeeding after tube feeding
- Providing information to families about the non-nutritive benefits of breastfeeding

### Section 3: Your experience and training within infant feeding

3.1 Do you have any kind of additional responsibility specifically related to infant feeding on your ward? (Choose one)

- Yes (please specify)
- No

3.2 Do you have any of the following breastfeeding credentials? (Allow more than one)

- IBCLC
- Breastfeeding counsellor
- Peer supporter
- Something else
- None of the above

3.3 Have you attended any of the following training? (Allow more than one)

- IBCLC preparation courses
- Online lactation training courses providing 50–90 hours of training
- Peer support training
- UNICEF 2-day breastfeeding training
- UNICEF eLearning for paediatric nurses
- Other training

3.4 During the course of an average week, how often do you provide clinical care to a breastfed child? (Choose one)

- Every shift
- Most shifts
- Rarely
- Never

3.5 On an average shift, I feel confident about being able to answer any questions about breastfeeding that arise. (Choose one)

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

3.6 When you remember your initial training, how much education did you receive in relation to breastfeeding? (Choose one)

- We had a whole day of training
- We had 1–2 hours of basic training
- It was assumed we would learn on the job
- I can't remember having any information about breastfeeding
- Other

3.7 Thinking back to the training you have received (not including any personal experience), to what extent do you agree that your training equipped you to be able to support breastfeeding families on the ward? (Choose one)

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

### Section 4: Post-registration training and continuing professional development

4.1 Thinking about the training you have received *after* qualifying, is breastfeeding training something that you have been provided with? (Choose one)

- Yes, it is mandatory
- It is offered, but not mandatory
- No, it is not provided



4.2 Is there someone on the ward or department where you work who has been identified as someone with additional infant feeding/breastfeeding expertise? (Choose one)

- Yes
- No
- I'm not sure

4.3 I feel that breastfeeding training is something I need or could benefit from. (Choose one)

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

4.4 In paediatrics, you need different skills and tools to be able to adequately support breastfeeding to continue, compared with people supporting healthy infants and children. (Choose one)

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

4.5 Have you ever asked for breastfeeding training from your ward manager? (Choose one)

- Yes, and I have received it
- Yes, and I wasn't given any
- No, I've not asked

4.6 If you have not asked for breastfeeding training, could you explain your reasons for this?

4.7 In your opinion, what would help you to be better able to support breastfeeding families on the ward or department where you work? (Allow more than one)

- A breastfeeding policy
- Better undergraduate training
- Specific breastfeeding training that relates to the care of sick children
- Leaflets and handouts available to give to parents on the ward
- A designated paediatric infant feeding team
- Something else?
- I'm not sure

4.8 I believe that breastfeeding is important for children, whether they are unwell or healthy

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

4.9 I believe that supporting parents to reach their breastfeeding goals is an important part of my job

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Thank you, this is the end of the questionnaire. Thank you for your time, your responses are very much appreciated.

If as a result of taking part you have any questions or concerns about your wellbeing, we encourage you to contact your midwife, health visitor or GP who can provide you with further information and support. If you have questions about the support or training provision in your department, you can ask your manager.

If you have any questions about your own personal feeding experience, you can also contact one of the breastfeeding organisations:





- National Breastfeeding Helpline 0300 100 0212.
- Association of Breastfeeding Mothers 0300 330 5453.
- La Leche League 0345 120 2918.
- National Childbirth Trust (NCT) 0300 330 0700.
- The Breastfeeding Network Supporter line in Bengali and Sylheti: 0300 456 2421.

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# Healthcare professionals' perspectives on dietary advice provided to people with an ileostomy

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## Abstract

**Background:** Diet is a common concern among people with an ileostomy as it can be associated with serious and burdensome complications, for example, dehydration and obstruction, and dietary advice is often unsatisfactory. In this study, we explored healthcare professionals' (HCPs) perspectives on dietary advice for ileostomy management.

**Methods:** Semi-structured interviews were conducted with HCPs, from multiple professions, who provide dietary advice to patients with an ileostomy. A framework approach to thematic analysis was used to understand and compare HCPs' experiences, beliefs and attitudes that influence how dietary advice is provided and the effectiveness of dietary management.

**Results:** Findings from interviews with 21 HCPs, across 3 hospitals, related to 7 key themes: tailoring of dietary advice to the patient, patient autonomy and communication, HCP knowledge and understanding, patient pathway, mixed messages, access to formal and social support and patient understanding and relationship with dietary advice. Profession was a strong determinant of what and how dietary advice is provided; however, closer team working increased consistency in dietary advice. Lack of scientific research and consensus contributes to mixed messages and reduced confidence in dietary advice for people with an ileostomy. Due to individual differences between patients, experiential learning with diet is key to self-management and is encouraged in a controlled way by HCPs; however, a lack of 'one-size-fits-all' guidance can be difficult for some.

**Conclusion:** The study findings should inform HCPs caring for patients with an ileostomy, and researchers designing and evaluating interventions, to improve how patients receive dietary advice for ileostomy management.

## KEYWORDS

diet, healthcare professional, ileostomy, qualitative, stoma

## Key points

- Semi-structured interviews were conducted with 21 healthcare professionals (HCP) to explore their perspectives on dietary advice for people with an ileostomy.
- A lack of research and expert consensus contributes to mixed messages and reduced confidence in dietary advice for people with an ileostomy.

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- Greater interdisciplinary working increases consistency in dietary advice for ileostomy management.
- HCPs' role involves providing guidance and support to people with an ileostomy while they develop the ability to self-manage their diet through experiential learning.
- This study provides a detailed picture of the provision of dietary advice to people with an ileostomy, within the NHS, which should encourage HCPs to reflect on potential pitfalls as well as components of good practice, to improve how patients receive dietary advice for ileostomy management.

## INTRODUCTION

Several thousand people have a stoma placed every year in the United Kingdom, with colostomies and ileostomies being most common.<sup>1</sup> Gastrointestinal (GI) stomas, such as an ileostomy, alter bowel function and in turn may influence dietary choices. People with an ileostomy are more susceptible to diet-related problems than people with a colostomy due to having a shorter-functioning GI tract.<sup>2</sup> Ileostomy formation is a life-changing operation, which can increase quality of life (QoL) for some, for example, people with severe inflammatory bowel disease (IBD), but also have negative consequences that people may then have to live with for many years.<sup>3–5</sup> Common complications include high stoma output and blockage,<sup>6,7</sup> which can have serious consequences in terms of physical health and QoL. Wind and odour are also common problems impacting QoL.<sup>8,9</sup> People with an ileostomy frequently modify their diet to manage these issues and report that dietary implications of their ileostomy affect daily life.<sup>5,10,11</sup>

Although people have been studying dietary effects on ileostomy function since the 1970s, the research is not comprehensive, or findings conclusive, likely due to the difficulty in isolating the effects of specific dietary components, as well as GI differences between individuals with an ileostomy.<sup>12</sup> Consequently, there are concerns regarding the perceived clarity and helpfulness of dietary advice being provided to people with an ileostomy from various sources, including healthcare professionals (HCP) and institutions, charities and support groups and stoma care companies, which can be a significant source of anxiety and confusion and prevent optimal stoma management.<sup>11,13</sup>

Understanding current practice, knowledge and beliefs is important to identify where further research is needed and how provision of dietary advice may be improved. The aim of this study was to explore HCPs' perspectives on dietary advice for management of an ileostomy.

## METHODS

### Study design

This study employed thematic analysis of in-depth, semi-structured interviews, using the framework approach,<sup>14</sup> to address the following research questions:

- 1) How is dietary advice provided to people with an ileostomy?
- 2) What factors influence how dietary advice is provided to people with an ileostomy?
- 3) What factors influence how effective dietary management is for people with an ileostomy?

### Sampling and recruitment

HCPs from three NHS hospitals (two large specialist teaching hospitals and a smaller district hospital in England) were recruited and interviewed. Participants were recruited from multiple sites to get a broader perspective, as participants of the same profession working at the same hospital may provide similar dietary advice as they work closely together and use the same patient-facing resources.

A combined purposive and snowballing sampling strategy was employed to identify and recruit the key providers of dietary advice to people with an ileostomy at each site. HCPs who provide dietary advice to adults with an ileostomy as part of their role were eligible. Participants were recruited and interviewed between December 2018 and August 2019.

Purposive sampling was used to recruit a representative breadth and depth of HCPs in terms of profession and location. A quota was set of a minimum of five of the following HCPs, considered to be the key providers of dietary advice to people with an ileostomy: stoma nurses, dietitians, surgeons and gastroenterologists. This quota was informed by the recommendation of Onwuegbuzie and Leech<sup>15</sup> to include at least three cases from each subgroup (e.g., dietitians) for comparison between subgroups when using qualitative methods and interviews.

## Data collection

Semi-structured interviews with HCPs were conducted face to face at their place of work. The interviewer (A.M.) used an interview topic guide (in Supporting Information) that was developed based on the clinical experience of members of the research team, concepts suggested in the literature and the experiences and advice of stakeholders (HCPs) and members of a patient and public involvement group (public contributors with recently formed ileostomy). The topic guide was piloted on the first two participants. Then, it was reviewed by A.M. and A.S., but no further amendments were deemed necessary. Further into the interview process, an additional question ('Do you think this approach/practice is typical for your profession?') was identified and subsequently asked when deemed appropriate.

Informed consent was obtained before each interview. All interviews were audio-recorded and transcribed verbatim. Interview transcripts and notes were anonymised prior to analysis.

## Data analysis

The interviewer adopted a reflexive approach<sup>16</sup> throughout the interview process and analysis by documenting and reflecting on her values, biases and potential influences as a dietitian who had recently worked in clinical practice and previously provided dietary advice to people with an ileostomy.

Interview data were analysed using the framework method of thematic analysis following a combined inductive and deductive approach (Table 1).<sup>17</sup> Initially, three transcripts were independently coded by two authors (A.M. and A.S.) and then discussed to reach consensus on the coding framework. The codes were grouped into categories and sub-categories that formed the organisational structure for the framework matrix (Table 2). Interview transcripts were then coded and charted (summarised by code/sub-category) by A.M. in accordance with the framework. A subset of interview data were independently coded (about ≈33%), and charting was checked, by A.S./G.H./C.E. NVivo

software (QSR International Pty Ltd.) was used to facilitate data management during analysis.

The completed framework matrix was used to conduct comparative descriptive and explanatory thematic analysis to identify key themes relevant to answering the research questions, considering potential influences of professional role and institutional setting.<sup>14</sup> Findings were compared and discussed between A.M. and the other authors within the multidisciplinary research team until consensus was reached, providing a broader perspective and moderating bias in interpretation.<sup>17</sup>

## Ethics

The Health Research Authority and the local Research Ethics Committee approved this study. The study was also accepted on to the National Institute for Health and Care Research (NIHR) Portfolio.

## RESULTS

### Participants

Twenty-one HCPs were recruited across the three study sites (hospitals). Characteristics are presented in Table 3. Interview length ranged from 12 to 67 min, with a mean length of 39 min.

### Key themes

The framework analysis of participant interview transcripts led to the development of seven key themes in relation to the three research questions. These are presented in Table 4 alongside HCP quotes from participant interviews that informed each theme.

### Tailoring of dietary advice to the patient

Differences in needs and experiences relating to dietary management, between IBD and cancer patients, were

TABLE 1 Analysis approach.

Stage of data collection and analysis process	Inductive or deductive approach
Topic guide developed to prompt participants to talk about topics identified by researchers and stakeholders (clinicians and patients) to be relevant to answering the study research questions	Deductive
Opportunities provided during the study interviews for additional topics to be raised by participants	Inductive
Coding framework developed from data across all interview transcripts	Inductive
Data charted into framework	Deductive
Themes identified, from comparative framework analysis, that contribute to answering the research questions	Deductive

TABLE 2 Framework matrix structure.

Categories	Sub-categories (codes)
1. Content of dietary advice provided	1.a Advice on diet
	1.b Advice on fluids
	1.c Medical management of the ileostomy
	1.d Adaptation of advice for comorbidities
	1.e Adaptation of advice for dietary preferences
2. How is dietary advice provided?	2.a Format of dietary advice
	2.b Setting in which dietary advice is provided
	2.c Timing of dietary advice
	2.d Communication between HCP and patient
	2.e Communication between HCPs
3. Organisational factors	3.a Role identity <sup>a</sup>
	3.b Role conflict <sup>b</sup>
	3.c NHS resources and priorities
4. Priority of dietary advice	4.a Priority for patient
	4.b Priority for participant
	4.c Priority within patient's care
	4.d HCP confidence in dietary advice
5. What informs dietary advice?	5.a Clinical experience
	5.b Formal guidance
	5.c Awareness of research
6. Patient experiences of diet and ileostomy	6.a Diet-related problems with ileostomy
	6.b Impact on day-to-day life
	6.c Conflicting information
	6.d Online advice and support
	6.e Experience-based learning with diet <sup>c</sup>
7. Patient engagement with dietary advice	7.a Patient understanding of dietary advice
	7.b Patient attitudes to dietary advice
	7.c Factors influencing adherence to diet advice

Abbreviation: HCP, healthcare professional.

<sup>a</sup>For example, what is expected/possible within professional role.

<sup>b</sup>For example, where other professions undermine advice given.

<sup>c</sup>For example, individual patient trial and error to identify links between diet and symptoms.

perceived by several HCPs. In addition, there was an awareness that patients with an ileostomy sometimes had comorbidities that required dietary management (e.g., diabetes), and these patients required specialist and adapted dietary advice.

TABLE 3 Participant characteristics.

	Number of participants
Profession	
Stoma nurse	5
Dietitian	5
Colorectal surgeon	5
Colorectal specialist nurse	4
IBD specialist nurse	1
Gastroenterologist	1
Site	
Specialist teaching hospital (site 1, s1)	10
District general hospital (site 2, s2)	3
Specialist teaching hospital (site 3, s3)	8

Abbreviation: IBD, inflammatory bowel disease.

Dietitians commonly spoke of how they adapted dietary advice to patient preferences and lifestyle. Stoma nurses also mentioned this. In particular, vegetarians and people who usually ate a high-fibre diet were identified as requiring additional reassurance and explanation of the dietary advice provided due to the contrast to their usual diet and conflict with their beliefs relating to a healthy diet.

## Patient autonomy and communication

HCPs were aware that patients with an ileostomy commonly had a need for self-determination in terms of their diet, stoma output and management. Most HCPs believed that patients need to find a personal balance that works for them, through controlled experience-based learning ('trial and error'). This belief informed how they provided dietary advice: providing general principles and guidance on gradual reintroduction of higher fibre and other potentially problematic foods to promote patient autonomy with dietary management.

HCPs used several communication styles to deliver dietary advice which could have affected patient autonomy with their dietary management. Advice, particularly when delivered by surgeons, was often communicated in a way akin to a traditional paternalistic approach, with the HCP informing the patients of what they should or should not eat and drink. Other HCPs spoke of compromising with patients, particularly in relation to fluid restrictions and oral rehydration solutions, suggesting an element of shared decision-making. Another common approach used by HCPs was more aligned with the information-giving model, where information on possible consequences of eating certain foods was provided but the decision of what to consume was left up to the patient.



TABLE 4 Participant quotes for key themes.

Research question	Key theme	Quotes from HCP participants
How is dietary advice provided to people with an ileostomy?	Tailoring of dietary advice to the patient	<p>I suppose it depends on the previous experience of patients. A lot of patients that I see with colitis, who have had diarrhoea, will know the sort of foods that give them diarrhoea and therefore principles of it, although not exactly the same, are kind of there already. ... For the people who go from nothing to having a stoma, you'll probably be a bit more prescriptive because they're going from a situation where they just don't really know what's going on, it's completely foreign. They may want some more guidance I guess so I'll probably be a bit more prescriptive in those sorts of situations. (Surgeon, s3)</p> <p>One patient I had recently ... she was vegetarian/vegan, so therefore she was having ... very high fibre content. ... She was very upset about the idea of not having a high fibre [diet]. But, when we explained and discussed what fibre is ... and that actually, once her gut had completely healed..., she would be able to slowly start phasing ... fibre back in ... it is individualising it for each patient. (Dietitian, s3)</p> <p>Some of our patients that come in who are diabetic ... we are talking about having a really high stodge, starchy diet, and they are like, 'Whoa. This is nothing I've ever been told before'. Then we know that we can also coordinate and liaise with nutrition [diabetes] nurses and dietitians who can ... offer a little more input on that side. (Stoma nurse, s1)</p>
	Patient autonomy and communication	<p>I give them no dietary advice; unless they say, 'Am I going to be able to eat and drink afterwards?' and I say, 'You should be able to eat and drink normally', knowing that that's perhaps not quite true because if they have problems, they might have to modify their diet. I almost don't worry them with, 'Oh no, you're going to need to cut out all of that'. (Surgeon, s1)</p> <p>There are some things ... patients are resistant to. ... And is that partly that they're ... trying to have, their own self-determination? ... 'I will eat what I want!'. (Stoma nurse, s1)</p> <p>If I give them the advice, I expect them to take it. That said, I know that they won't always ... some of them will say, 'Well, I can't do that all the time'. You know that they aren't fulfilling the whole diet because it's unpalatable. So ... you often have to just compromise a little bit. (Surgeon, s1)</p> <p>So, it depends on the patient and our negotiating skills with them. (Dietitian, s2) I say to them, 'You may eat something, and it causes lots of wind or a looser output, but as long as it's not having detrimental consequences, it's up to you what you do. You might decide, I'm going to have it, but I'm going to have it when I'm at home all day. Therefore, it doesn't matter that I've got all this air coming out'. (Dietitian, s3)</p> <p>In that sort of situation people want to take ownership of their ongoing treatment and feel that they're not diseased anymore. This is normal for them and therefore they need to be in charge of it. (Surgeon, s3)</p> <p>They're in charge of their stoma and their output and things like that. You try and give them back control. (Stoma nurse, s2)</p>
What factors influence how dietary advice is provided to people with an ileostomy?	HCP knowledge and understanding	<p>It may be that I am a bit more of a coordinator but I'm not going to be able to give as good advice probably as a dietitian or a stoma care practitioner. (Surgeon, s3)</p> <p>Certainly, some of the health professionals maybe don't have such a good knowledge of the changes or alterations of fibre in different foods and might just give a blanket approach of no fibre or just list a very small range of foods to cut out, which the patient then takes away as, 'The range of foods I mustn't eat'. Actually, there's a broader range, better advice or more comprehensive written information that can help them to understand. (Dietitian, s1)</p> <p>My knowledge of it is not great, so I probably get bits of it wrong. (Colorectal specialist nurse, s1)</p> <p>Certainly, from the stoma care nurses and the cancer nurse specialists; we often see patients jointly together in outpatient clinics; but</p>

TABLE 4 (Continued)

Research question	Key theme	Quotes from HCP participants
	Patient pathway	<p>particularly when you're planning surgical intervention and when you're seeing patients in the postoperative setting, you get familiar with the generic advice that tends to get given. (Surgeon, s3)</p> <p>I always called it a low-residue diet, and then we had kind of a dietary drive on the ward, where patients were placed onto an A to E diet, A being sips, and E being normal diet, and then the graded in-between. That was borne out of all of us nurses calling every sort of diet a different sort of diet, and then the patients were getting confused. (Colorectal nurse, s3)</p> <p>One booklet is talking about low residue and then other people are talking about low fibre. Other people are talking about low insoluble fibre but high soluble. So actually, what should we be doing? I'm quite experienced in it, but even I'm confused.... Should I be promoting soluble fibre or is that too much initially? Should we work towards having higher soluble after a few weeks or a couple of months of eating? (Dietitian, s2)</p> <p>We do get a lot of advice from our dietitians. We work really closely with them and if we feel that somebody is struggling, even with the information, ... – they haven't got a high output stoma, they've got a normal functioning ileostomy – we do tend to get the dietitians involved, even in the hospital, so that they give guidance and then we're talking about the same thing because we really want to be driven by what they're saying as well. (Stoma nurse, s3)</p> <p>I would say it doesn't help ... that the ileostomy services are probably going to come under the dietetic surgical service in hospital and then when they go home, they're going to split up into two different camps. The colorectal surgery patients or the colorectal cancer patients and the IBD patients, and there's different dietetic services that support both of them and neither one of them has the ability to see patients quite as quickly as some other areas. (Dietitian, s1)</p> <p>I think at certain points they go into windows of time where, if they're having difficulty, they possibly don't have quite so much access to it [dietetic services]. That is largely dictated by what services are funded at different points of patients' pathways. I think the greatest gap is probably between inpatient and outpatient services. (Dietitian, s1)</p>
What factors influence how effective dietary management is for people with an ileostomy?	Mixed messages	<p>On one side [of the booklet] it has got listed all the foods that you can eat that ... are good for you, and, at the top, foods that will help thicken an output. ... And in the middle section ... will be foods that you can eat but you might need to be a bit more cautious about, and then at the bottom might be some foods that we say, 'be very cautious about to start off with, when you are first starting to eat'. (Stoma nurse, s3)</p> <p>Just looking from one table of what to eat and what not to eat, from one booklet to another trust booklet, actually, it is quite different. Some people are allowed iceberg lettuce; other people aren't. So, it's like, 'Well, which one can you do?' ... I'm like, 'Well, I don't know. It depends which booklet you follow'. (Dietitian, s2)</p> <p>If one healthcare professional is giving them very stringent advice and a list of absolute no-go foods, and someone else is saying, 'Well, actually try this and see what happens', that advice can be very confusing for patients. (Dietitian, s1)</p> <p>'If you really, really want some peanuts ... then eat them [in] small amounts, not all at once, and have some fluid'.... You see you're always contradicting yourself I feel with this, with ileostomy advice, because you're saying, 'Well drink a bit of water with that. And oh, don't eat and drink at the same time'. (Stoma nurse, s3)</p> <p>There's a lot of confusing advice about whether they should increase their fluid intake, what that fluid should be. ... There's a lot of well-meaning incorrect advice given both from family, friends, often healthcare professionals too and certainly on internet fora where people say, 'Don't get dehydrated, make sure you drink plenty of water'. (Surgeon, s3)</p>

(Continues)

TABLE 4 (Continued)

Research question	Key theme	Quotes from HCP participants
		It's very powerful sometimes for patients to hear things from people who seem to have a similar experience. That seems much more powerful than a health professional telling you, so it can have a much bigger effect and a much bigger impact ... and then we go in and go, 'No, actually, what you said wasn't right'; ... you don't always know what they've been told as well.... So, inside them, they can often be conflicted, and that's hard. (Stoma nurse, s1)
	Access to formal and social support	<p>The stoma nurses ... are seeing everybody. We are only getting the further patients who are having problems with it. (Dietitian, s3)</p> <p>If it was a high stoma, so in other words, more proximal to the small bowel, I think we would be thinking of getting dietitian advice for that in hospital. Again, I would default to the dietitian to come and advise on what might be more beneficial for them. (Surgeon, s1)</p> <p>We leave it to the patients to get in touch with us. ... We probably don't leave the door ajar enough. (Surgeon, s3)</p> <p>The patients that are 6 months out and they think, 'Well, my stoma nurse is busy' or 'She doesn't want to see me now. She only saw me at the beginning' and 'I don't really know who to go to'. (Stoma nurse, s1)</p>
	Patient understanding and relationship with dietary advice	<p>People do really struggle ... with not being allowed to drink very much, especially if their IV fluid management isn't, maybe, quite as good as it needs to be. They can often feel so thirsty and quite distressed by that, especially when it's hot. (Dietitian, s2)</p> <p>Sometimes, [the patient] can be really motivated, very interested in it, and just want to do whatever they can; they're really engaged, and with a supportive family ... just doing everything that they can. (Dietitian, s2)</p> <p>They don't remember about adding anything else in, you know, just trying to build up their diet. ... I keep thinking, is it because we're giving too much information at certain times? (Stoma nurse, s3)</p> <p>I suspect the general understanding, within the populous, of dietary advice generally – what's a high fibre fruit, vegetable, that type of thing – I think it's probably very poorly understood. So, I suspect, for many patients, they get given some advice but are bamboozled by it. (Surgeon, s3)</p> <p>What I'm trying to do all the time is ... give [patients] enough information so that they understand why I'm telling them this, so that they can start to make those adjustments themselves, so they can think. So, one of the things I might say is that they keep a food diary. ... I don't know how many patients do that, but for me it's about reminding them that there is a link between what they're putting in their body and what will come into the bag. (Stoma nurse, s1)</p> <p>The ones who probably have the best concept are the repeat offenders who come in with multiple episodes of bowel obstruction. They know what sets it off, they still eat it anyway because sometimes you just can't help yourself and then they come in and they go 'I know'. (Surgeon, s3)</p> <p>I think the wind and the bloating and leakages are massive problems for some people. ... Because ... the bag blows up with air, and they can't hide the fact that they have a bag, which I think they struggle with. (Dietitian, s3)</p> <p>It can become quite a point of obsession ... by ileostomy patients in particular ... they are so restricted in what they can eat that they are missing out on some of the essential nutrition they should be receiving, because they are so worried about what they should and should not be having. (Stoma nurse, s1)</p> <p>There are the social issues as well. .... Sometimes they're just having to eat a completely different meal to the people they're with. (Dietitian, s1)</p>

Abbreviations: HCP, healthcare professional; IBD, inflammatory bowel disease; s1, site 1; s2, site 2; s3, site 3.

## HCP knowledge and understanding

Stoma nurses were the main providers of dietary advice because they saw all patients with an ileostomy, whereas dietitians, although considered as experts, were referred patients only with complications requiring dietary management.

Many HCPs lacked confidence in dietary advice provided, for several reasons: (1) variation in content and quality of advice and conflicting information from different sources; (2) lack of evidence to inform or support dietary advice, particularly with respect to long-term effects of dietary modification; (3) poor patient adherence to dietary advice; and (4) insufficient dietetic resource and training/guidance for non-dietitians.

HCPs advised avoiding a high-fibre diet to manage high output. Within this, reducing insoluble fibre was key. However, dietitians expressed uncertainty about whether soluble fibre should also be restricted, due to a lack of evidence.

HCPs relied on experiential learning for knowledge acquisition due to a lack of time for structured activities such as research, audit or reviewing literature. Although confidence in awareness of relevant research varied, most HCPs identified a lack of research evidence to inform or support dietary advice for ileostomy management. Absence of published evidence-based guidelines meant that local and profession-specific guidelines, although limited, were relied upon to provide some consistency and reference for practice.

## Patient pathway

Patients have an ileostomy for many different reasons, due to a range of conditions and in a variety of circumstances. As such, they come under the care of different multidisciplinary teams (MDT), and some have no formal MDT at all. Condition-specific MDTs facilitated cross-disciplinary learning and collaborative patient care.

Differing care pathways affect access to support from HCPs, for example, dietitians and specialist nurses. For patients with an ileostomy due to colorectal cancer or IBD, the specialist nurse for their condition was their main point of contact before and after their hospital stay for ileostomy formation.

It was highlighted that at some points in the patient care pathway, routes of communication between HCPs, and between patient and HCPs, were weakened or severed, leaving some patients the need for dietary advice and support unmet.

## Mixed messages

There was an awareness among HCPs that patients may receive mixed messages on dietary management. HCPs

were influenced by differing priorities and therefore presented inconsistent dietary advice to patients. In addition to interdisciplinary and inter-individual variation and contradictions, one HCP was aware that a general lack of clarity on dietary management for ileostomies meant her advice could at times appear contradictory.

Variation in terminology also contributed to unclear and mixed messages. HCPs agreed that patients should follow a low-fibre diet during the early post-operative phase of recovery after ileostomy formation, particularly if output was watery/high. However, how this diet was described to patients was inconsistent and confusing. Additionally, printed material offering differing advice could be confusing. Close multidisciplinary working facilitated clarity and coherence in dietary advice provision.

Stoma nurses, and sometimes surgeons, provided some dietary advice preoperatively, but this was limited in the hope that it would reduce patient worries. However, booklets containing dietary advice in the form of lists of problematic foods were often given to patients along with other preoperative information, leading to potentially conflicting messages at a time when patients may be overloaded with information. HCPs also perceived that patients receive conflicting anecdotal advice from informal sources such as family and online forums.

## Access to formal and social support

Post-operatively, the surgical team (consultant surgeons and their team of surgeons/doctors), and to some extent stoma nurses, acted as gatekeepers to determine which patients received specialist advice from a dietitian. Dietetic input was reliant on other MDT members acknowledging and valuing dietitians' expertise, as well as availability of dietetic resource.

Despite various potential sources of dietary advice for patients undergoing ileostomy formation, HCPs were aware that many patients did not receive sufficient support with dietary management. Outside of the healthcare system, HCPs felt that dietary advice and support received from other sources (e.g., family, online forums) was a strong influence on patients that had potential to either help or hinder dietary management.

## Patient understanding and relationship with dietary advice

Poorly controlled stoma output and dietary restrictions were considered to have many negative consequences on daily life for people with an ileostomy. Consequently, HCPs reported that patients can become obsessed with their diet due to high anxiety about consequences, such

as high output and blockage, and insufficient understanding of how best to manage their diet. Lists of foods associated with symptoms and complications are often interpreted as lists of foods that should always be avoided. This meant that some patients have a very restrictive diet, often unnecessarily.

Conversely, one HCP reported that some patients readmitted with obstruction knew what they had eaten that caused it and acknowledged they had eaten it knowing the risk.

A lack of understanding of basic dietary principles, such as what fibre is, was thought to be a particular barrier to good dietary management. Another barrier was information overload during the perioperative period. Elective patients were given a very large amount of written information prior to ileostomy formation.

Those with a permanent ileostomy or those who were younger were perceived to seek out more information and support and take ownership of their stoma management, whereas those with a temporary ileostomy tended to be less engaged and have less understanding of dietary management.

### Comparison between professions and institutions

Dietary advice is provided to people with an ileostomy in many different, and often opposing, ways. Variation comes from differences in (1) sources of advice, that is, professional and peer support; (2) format, for example, verbal, printed or online; (3) purpose, for example, patient education versus response to patient query; (4) specificity, that is, general versus tailored advice; (5) setting, that is, inpatient versus outpatient; and (6) communication style. This variation contributes to patients receiving mixed messages, one of the key themes.

Findings from our comparative, explanatory analysis help to explain the considerable heterogeneity in how dietary advice is provided to people with an ileostomy. Contributing factors include differences in knowledge acquisition, power and influence, professional training and priorities, organisational structure and resources, individual differences and degree of patient autonomy, in addition to a lack of strong research evidence for dietary management.

HCPs agreed that patients should follow a low-fibre diet post-operatively, with insoluble fibre being the key component to reduce. However, the role of soluble fibre for people with an ileostomy was less clear due to a lack of knowledge and consensus. Only dietitians discussed potential differences between insoluble and soluble fibre for ileostomy management. Specific foods were highlighted as problematic, but this varied by HCP. Dietitians focused their advice more on an overall low-fibre diet rather than labelling individual foods as high risk.

There were some discrepancies in advice HCPs were reported to provide versus their experiences with some

colleagues and patients regarding dietary advice provision. Participants spoke of recommending high-fibre foods be gradually reintroduced with the aim of patients returning to a more normal and balanced diet long term. No HCP described advising patients to follow a very restrictive diet long term; however, there were several reports of patients having followed a strict diet much longer than necessary in the belief that they were following the guidance they were given.

Professional role, in terms of perceived responsibilities and priorities, was a key factor determining dietary advice provided to people with an ileostomy. Stoma nurses and dietitians used a combination of written and verbal advice and often checked current understanding and repeated advice at different time points. Other professions provided more ad hoc verbal advice. Where individuals and professions worked more closely together, there was increased sharing of knowledge and learning which facilitated greater consensus and consistency in dietary advice.

## DISCUSSION

HCPs expressed belief that good communication and understanding are key to effective dietary management for people with an ileostomy. However, they also acknowledged that mixed messages commonly cause confusion and limit patient understanding and confidence in dietary advice. Variation in content and quality of advice, lack of research evidence, poor adherence and insufficient training and access to dietitians all contributed to a general lack of HCP confidence in dietary advice provided to people with an ileostomy.

This study, and a previous qualitative study of patients undergoing colorectal surgery within an Enhanced Recovery After Surgery programme,<sup>18</sup> found that during the perioperative period, patients receive a large, potentially overwhelming, amount of information from various HCPs. This is at a time when they are under considerable stress and unwell and/or recovering from major surgery.

Information provision should be adapted to consider the patient's capacity and desire, in the immediate context, to engage with new information.<sup>19</sup> Several HCPs expressed an awareness of this and adjusted the amount and format of dietary advice accordingly: for example, providing small amounts of information using a paternalistic communication style immediately post-surgery and then moving to more of an information-giving or shared decision-making approach later in the recovery process. Some HCPs also tailored dietary advice to individuals in terms of the patient's prior knowledge and beliefs, dietary preferences and comorbidities.

In a quasi-experimental trial, Webber et al.<sup>20</sup> showed that combining written and verbal information, checking understanding and repeating and emphasising key points



improved patient recall of information provided. In the current study, stoma nurses and dietitians used a combination of written and verbal advice and often checked current understanding and repeated advice at different time points.

Coherence of dietary advice intersects with concordance of health beliefs between patient, HCPs and family and social support networks in determining behaviours. HCPs perceived similar beliefs between HCPs and patients regarding priorities for dietary management of ileostomy, that is, avoiding blockage and reducing risk and consequences of high output. Many HCPs and patients shared the belief that dietary management needed to fit in with the patient's lifestyle. However, there appeared to be inconsistency in the assessment of risk associated with some dietary components and potential consequences/complications, between patients and HCPs and other members of patients' family and support networks.

Dietitians' focus on an overall low-fibre diet rather than labelling specific foods as high risk may be due to the reason that patients are referred to the dietitian, for example, those requiring assistance with managing high output, whereas specific foods highlighted by surgeons and stoma nurses tended to be those considered to increase risk of obstruction.<sup>21</sup> Additionally, dietitians are trained to provide a whole diet approach.<sup>22</sup> The lack of clarity and consistency between HCPs on the role of soluble fibre is in keeping with a general lack of clarity in the literature.<sup>23,24</sup>

HCPs suggested several factors that determine patients' behaviour in response to receiving inconsistent advice. Firstly, there was a perception among other HCPs that any advice provided by the surgeon tended to carry much weight with patients even if brief or non-specific. Surgeons acknowledged that they were not the experts on dietary management and often referred to the dietitian or stoma nurse for input. However, despite this and having limited awareness of whether their advice was consistent with that of other HCPs, they still gave some advice on diet. Secondly, it was assumed that anecdotal peer experience can undermine HCP advice. This may be due to an increased feeling of relatedness with peers and potentially be less likely to occur where the HCP has developed a good rapport with the patient, listened to and addressed their concerns, and checked understanding.<sup>25</sup> Thirdly, HCPs were aware that patients are more likely to follow advice that fits with their beliefs and lifestyle.<sup>26</sup>

HCPs believed that patients with an expectation that their ileostomy was temporary lacked ownership of their stoma management. In contrast, patients with a permanent ileostomy were perceived to want to take ownership. HCPs were aware of the important role diet played for people with an ileostomy as something affecting their health and stoma function that they could control. Patients often asked HCPs for more dietary advice to

increase their self-efficacy (via increased knowledge and understanding) in managing their diet and ileostomy. This suggests positive outcome expectancies for dietary management. Behaviour-specific efficacy is a strong determinant of health behaviours in those who place high value on their health, although the health locus of control construct has little influence on behaviour.<sup>27,28</sup> As such, patients who ask for dietary advice, and receive what they need, are likely to have increased self-efficacy and more likely to make diet-related behaviour change.

Key components of patient-centred care are understanding the patient as a unique person with individual needs in terms of what and how advice is required, coordination of care, patient involvement in care and patient empowerment.<sup>19,29</sup> In this study, some aspects of these components were apparent, as discussed, but, overall, how dietary advice and management was provided to patients with an ileostomy fell short of being fully and consistently patient centred.

A systematic review of MDT co-management of surgical patients suggests that patient co-management between surgical and medical consultants in conjunction with wider MDT involvement can improve clinical outcomes.<sup>30</sup> MDT interventions included a daily or weekly MDT meeting, thus providing a regular opportunity for team members to discuss patient care more holistically. As such, MDT meetings are likely to increase consensus and consistency in patient care and advice. At the hospitals where our study participants worked, although the surgeon and stoma nurse were always involved in these patients' care, no formal MDT was in place for people undergoing stoma or ileostomy formation. Although patients with an ileostomy may be under a condition-specific MDT, for example, IBD or colorectal cancer MDT, many fall outside their remit. Also, due to the condition focus and possible lack of stoma nurse involvement (within the formal MDT), stoma management is unlikely to be an MDT priority.

Several factors may contribute to the phenomenon observed in this study of HCPs reporting to encourage patients to reintroduce foods and consume a balanced diet after the initial post-operative healing period, while also describing how many patients follow an overly restrictive diet for months or years after ileostomy formation due to inappropriate advice. It may be that participating HCPs had a greater interest in diet and nutrition which manifested as better knowledge and communication of diet advice than other colleagues. Additionally, or alternatively, this may be due to gaps in patient care meaning that patients miss out on follow-up advice and mixed messages from online sources.<sup>13</sup>

It would be uncomfortable for participants to acknowledge personal beliefs and behaviours that are non-coherent.<sup>31</sup> Therefore, participants are likely to have reported behaviours that match the beliefs they described and are less likely to have acknowledged, possibly even to themselves, where they do not. It is possible that, in

practice, circumstances, for example, lack of time, stress or insufficient training/experience in behaviour change skills, contribute to HCP behaviour that falls short of their intentions.

## Strengths and limitations

A strength of this study was having multidisciplinary perspectives in the analysis process, as it enabled initial beliefs and interpretations from interview data to be challenged, leading to deeper understanding and interpretation of data. Use of a rigorous framework approach<sup>14</sup> facilitated the key comparative element of the analysis.

As dietitians, the interviewers' professional role helped encourage participation, and shared experiences served to facilitate rapport with participants. Conversely, knowledge of the interviewers' profession may have elicited heightened fear of judgement for some HCPs.

Other study strengths include involvement of public contributors and HCPs in developing the interview topic guide; face-to-face interviews, in a place convenient and familiar to participants, facilitating rapport development and enabling the interviewer to respond to body language in addition to verbal cues; the interviewer's experience of working in the clinical setting, enhancing understanding and ability to quickly identify appropriate probing questions; interviews across a wide range of relevant HCPs; and all interviews conducted by the same researcher, providing consistency.

A limitation is that, although different-sized hospitals and a combination of teaching and district general hospitals were included, all sites were in the south-west of England which did not allow for identification of potential regional differences. Nonetheless, this meant that inter-site differences were more clearly attributable to the institutional structure (e.g., ways of working with other professions and size of department influencing opportunities for peer support and learning) than if regional differences had also been at play.

It must be kept in mind that all participants in this study were HCPs, and although patient behaviours and experiences were described, because there were no patient participants, these were HCP observations and perspectives that will be influenced by their knowledge, beliefs and experiences as an HCP. Additionally, experiences reported to HCPs by their patients were not observed first hand by the participants and will have been influenced by how patients interpreted information provided to them and patient relationships.

## Implications for practice

Consensus and consistency in provision of dietary advice to people with an ileostomy is important but difficult to

achieve when, firstly, several HCPs are responsible for providing dietary advice and, secondly, there is a lack of strong evidence or consensus guidelines for dietary management. A similar set of issues has previously been identified in the dietary management of IBD. However, evidence-based consensus guidelines have recently been developed using systematic review and Delphi methods, providing support for best practice although acknowledging the limitations of the current evidence.<sup>32</sup> A similar need for consensus guidelines for dietary management of ileostomies was highlighted by participants in the current study.

Integrating a stoma MDT with existing IBD and cancer MDTs may be difficult to establish, due to issues of logistics and resources, but could increase coordination of care and the clarity, consistency and comprehensiveness, and therefore effectiveness, of dietary advice. Formal MDTs improve communication between HCPs and would increase HCPs' knowledge and understanding of individual patients enabling a more holistic and tailored approach to provision of dietary advice, facilitating patient-centred care.

It is important for HCPs to take time to understand key aspects of their patient's beliefs and lifestyle to tailor dietary advice to the individual and implement shared decision-making where appropriate. This shows respect for the patient as an individual and is likely to reduce resistance to dietary changes and increase understanding. Patients should be encouraged to ask questions about their diet. Checking patient understanding and repeating advice at different time points are likely to improve patient recall of information provided.

Furthermore, advice giving should be adapted, in terms of communication style and content, to the patient's need at a specific point in time. HCPs should be aware of what else is going on for the patients that may affect their ability to positively engage with dietary advice, for example, the risk of information overload preoperatively, feeling unwell and vulnerable post-surgery while recovering in hospital, practical and emotional support from significant others (or lack of) or the need for autonomy over their long-term health and well-being.

Power dynamics also need to be acknowledged. For example, surgeons should consider that their position may influence patients to follow their advice above that of other HCPs even on topics that are not their speciality, such as diet. As such, they should be careful to ensure that any dietary advice they give aligns with that of their specialist colleague(s).

## CONCLUSIONS

How dietary advice is provided to patients with an ileostomy is inconsistent, and many patients do not receive adequate support with dietary management.

The profession of the HCP is a strong determinant of what and how dietary advice is provided. There were also some institutional differences in information provision, related to the structure and relationships within the MDT, with closer team working increasing consistency in dietary advice. However, a lack of research and consensus contributes to mixed messages and reduced confidence in dietary advice for people with an ileostomy.

HCPs and patients are motivated to promote self-management and self-determination with diet, because ileostomy formation involves long-term change in the patients' body and necessitates daily management. Experiential learning is key, and encouraged in a controlled way by HCPs, due to individual difference between patients. However, the lack of 'one-size-fits-all' guidance is a struggle for some patients, particularly those with high anxiety about the risk of complications.

This study provides a detailed picture and new in-depth understanding of the provision of dietary advice to people with an ileostomy. This should help HCPs working with patients with an ileostomy, and researchers designing and evaluating interventions, to understand potential pitfalls as well as components of good practice to improve how patients receive dietary advice for ileostomy management.

#### AUTHOR CONTRIBUTIONS

All authors contributed to the conception and design of the project. A.M. collected data. A.M., A.S., G.H. and C.E. contributed to data analysis. A.M. and G.H. contributed to writing the manuscript. All authors critically reviewed the manuscript and approved the final version submitted for publication.

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#### CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

#### TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

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#### PEER REVIEW

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Students' consumption of high and low nutrition foods and reduced plate waste by schools' wellness-related policies and garden program participation

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## Abstract

**Background:** Participation in school-based programs that may support children's nutritious dietary behaviours varies across schools. We examined school participation in wellness-related policies, school-based garden programs and students' dietary behaviours.

**Methods:** Among matching schools who did and did not participate in school-based garden programs, we analysed the lunches of 80 Pittsburgh Public Schools (PPS) students in 1st, 2nd, 6th and 7th grades during Autumn 2019 using digital food photography. We also acquired school wellness policy data. Using cross-sectional linear regression, we estimated the association between school-based garden programming, wellness-related policies and dietary outcomes, adjusting for grade.

**Results:** School's implementation of nutrition services policies was negatively associated with energy wasted from lunch ( $\beta = -44.7, p = 0.01$ ). The number of semesters the students' school had participated in the garden program was positively associated with students' whole grain consumption ( $\beta = 0.07, p < 0.001$ ).

**Conclusions:** Cross-sectional associations suggest that schools that are more engaged in wellness policies and garden programs may provide environments that are more supportive of students' nutrition than in other schools.

## KEYWORDS

child, dietary behaviours, gardens, nutrition, school policy

## Key points

- Schools' participation in wellness-related policies and school-based garden programs may support students' dietary behaviours.
- In cross-sectional analysis, we found that school's implementation of nutrition services policies was negatively associated with students' energy wasted from lunch.
- The number of semesters the students' school had participated in the garden program was positively associated with students' whole grain consumption.



## INTRODUCTION

Children consume between 19% and 50% of their daily calories at school<sup>1</sup>; thus, schools are key to increasing access to healthy foods and promoting children's healthy behaviours.<sup>2,3</sup> There are a range of effective strategies to increase students' consumption of nutritious foods at school.<sup>4</sup> School garden programs are attractive options because they allow for an active learning experience with the opportunity for education around healthy dietary behaviours at the same time as engaging students in learning and experiencing nature.<sup>5,6</sup> Such school garden programming efforts can also expose children to new types of fresh fruits and vegetables, as well as ways to grow and cook food, and both are associated with improved willingness to taste<sup>7–11</sup> and consumed produce.<sup>12–16</sup> Consuming fruits and vegetables reduces the risk of many preventable diseases, including cardiovascular disease, obesity and cancer.<sup>17,18</sup> Also, fruit and vegetable consumption is especially important for growth and development throughout childhood and children's dietary patterns often persist into adulthood, which can set the stage for disease inequities later in life.<sup>19</sup>

In a review of studies examining school garden impacts on student fruit and vegetable consumption, all 12 included studies reported statistically significant improvements in predictors of fruit and vegetable consumption, including preference, willingness to taste and knowledge.<sup>6</sup> However, the evidence supporting improvements in fruit and vegetable consumption was mixed, with some showing gardening interventions increased fruit and vegetable intakes, whereas others showed no change. In another systematic review of 14 gardening intervention studies, 10 reported small but statistically significant increases in fruit or vegetable consumption among garden intervention participants.<sup>20</sup> School environments vary with heterogeneous school climate or resources, which could introduce barriers or facilitators to program implementation and contribute to inconsistent findings. Furthermore, many studies relied on self-reported measures of dietary intake or even proxy reports from parents that are vulnerable to inaccuracy.<sup>20,21</sup>

Beyond gardens, quality wellness policies can support student health; however, resource (e.g., school personnel) constraints can hinder the development, maintenance and dissemination of school wellness policies.<sup>22</sup> For example, school nutrition practice may not reflect written policy language.<sup>23</sup> In addition to inadequate policy language, lack of enforcement can limit policy implementation.<sup>24</sup> Technical assistance from external partners can help schools connect to resources and services and tailor their approach to support successful policy development and implementation.<sup>25–27</sup> The Healthy Schools Program (HSP) is the largest program in the US aimed at school-based obesity prevention and at its core is evidence-based technical assistance.<sup>28</sup>

In Pennsylvania, HSP technical assistance has demonstrated increased policy impact on school wellness environments in five school districts.<sup>22</sup>

Together, these studies suggest that schools can support student health with effective wellness policies and potentially garden programming. Nonetheless, it is important to note that the degree to which schools implement health promoting strategies impacts their success. The present study was originally designed to examine whether and how Grow Pittsburgh's Learning Garden programming increased students' fruit and vegetable consumption at school. The COVID-19 pandemic and closing of school buildings made it impossible to follow the original protocol. We therefore leveraged individual-level student and school-level garden and wellness-related policies data collected during Autumn 2019 to describe how students' consumption of school lunch differed according to whether and the degree to which schools participated in garden programming (i.e., length of time a school had a garden) and HSP wellness-related policies.

## METHODS

### Description of the Learning Garden program

Grow Pittsburgh is a Pittsburgh community-based organisation with a mission of teaching people how to grow food and promoting the benefits of gardens. Grow Pittsburgh has been working with Pittsburgh Public Schools (PPS) to promote Learning Gardens for schools and students. Any school that is interested in participating in the program can apply to Grow Pittsburgh. Often, a school staff member initiates the process and champions the garden within the school. Each school is paired with a Grow Pittsburgh Garden Educator for 2 years to support teachers' use of the Learning Garden as a teaching tool, and to help schools build the groundwork for a thriving garden. Teachers bring students to the outdoor garden where they learn how to identify different plants, plant and care for crops, and harvest crops. Through the Learning Gardens, students are exposed to cooking and gardening throughout the year with activities that are integrated into the classroom curriculum. Classroom lesson plans include plant journals, lessons on farming practices, and cooking dishes that highlight the harvested vegetable. Learning Garden programming is tailored to the class grade, season and type of crop.

### Participants

To select classrooms, Grow Pittsburgh provided a list of schools and classrooms in the PPS that had been participating in the Learning Garden program and the

start date or expected start date for schools that were not yet participating. We then matched classrooms participating in Learning Garden programming or “treatment” classes to “control” (i.e., not participating in Learning Garden programming) classes first by district region (East, North/West and Central), and then based on school rates of economic disadvantage in the school's student population, percent of African American students within the school and grade. The resulting matched class pairs had similar school demographics. At all schools with selected classes (“treatment” and “control”), we first asked school principals to approve their school's participation in the study and verify the presence or absence of a garden on school premises. Next, we invited the teachers from the selected classes to participate. We identified class pairs across all grades from kindergarten to ninth grade. In the Autumn of 2019, we invited students to participate in the larger planned quasi-experimental study through letters sent home to parents in students' backpacks. A sample of 85 racially and ethnically diverse students from 1st, 2nd, 6th and 7th grades attending PPS (Autumn 2019) were agreed to participate in the study. Of the recruited 85 students, five students did not participate in digital food photography because they were absent on data collection days ( $n = 4$ ) or later declined to participate ( $n = 1$ ). The study was approved by RAND's Human Subjects Protections Committee. All parents provided active parental consent by signing our consent form and returning it to the team and children provided verbal assent.

## Digital food photography

We measured student meal intake during school lunch periods in Autumn 2019. Since 2014, the district has implemented the Community Eligibility Provision so that all students are entitled to free lunch regardless of their family's financial standing. As a result, most students consumed the school lunch. Although a few students brought their lunch from home, we photographed and analysed all lunches regardless of source.

Digital food photography allows researchers to quickly and unobtrusively estimate food intake in school cafeteria settings.<sup>29,30</sup> Two digital video cameras mounted on tripods placed 14 inches (~35.6 cm) from the tray of food were used to take the photographs. The tripods were 24 inches (~61 cm) tall, and the cameras were angled down at 45°. These methods allow the apparent size of all foods to remain constant across photographs.

To account for daily variability, we measured dietary intake on two different days. We tracked students with identification numbers. A laminated label displaying the student's identification number was placed on each students' tray, so that we were able to include it in the photograph and match the meal to the student. With the

help of teachers, study staff met participating students before they entered the cafeteria line. One member of our team gave each participant a numbered label, placed it on their lunch tray, and, after they left the cafeteria line, directed them to the camera station. Another team member photographed the plate of foods selected by each student with a digital video camera prior to and after the meal. For the few students who brought lunch from home, the lunch was unpacked at the camera station, and items were weighed and photographed before and after their meal with their numbered label. Data collection occurred quickly with little inconvenience to the students.

Images of precisely weighed standard portions of the foods served were also collected, and these food images were linked to the Food and Nutrient Database for Dietary Studies 2013–2014,<sup>31</sup> which allows energy and nutrient intake to be calculated. Food consumption was estimated using validated procedures that produce reliable and accurate food intakes among children.<sup>32,33</sup> Briefly, a computer application simultaneously displays on a computer monitor the digital photographs of the reference portion, food selection and plate waste. Registered dietitians estimate the percent of the reference portion of food selection and plate waste. Using the estimated proportions, the computer application calculates the amount of food eaten (food selection minus plate waste) and analyses the macro- and micronutrient composition of food selection, plate waste and food intake using the United States Department of Agriculture nutrient database. As previously demonstrated, agreement is high among the registered dietitians who estimated portion sizes, and overall portion size estimates of food selection, plate waste and food intake were highly correlated with weighed portion sizes (all  $r > 0.90$ , all  $p < 0.0001$ ).<sup>29,30</sup> Furthermore, mean differences between directly weighing foods and the digital photography method are less than 6 g.<sup>30</sup> For these analyses, we present amounts of fruits, vegetables, whole grains, dairy, added sugars, protein, total fat, carbohydrate, total sugars, fiber, calcium, iron, total energy selected, consumed and wasted.

## School health indices

In 2006, the Alliance for a Healthier Generation created the Healthy Schools Program to help schools implement evidence-based policies and programs that promote healthy behaviours.<sup>34</sup> The program provides free technical assistance so that schools can follow step-by-step practice standards and interactive progress monitoring through a national recognition program. Since 2016, PPS has been participating in Healthy Schools Program with training and technical assistance from University of Pittsburgh Medical Center (UPMC) Children's Hospital of Pittsburgh. All schools in our sample participate and, within each school, their Healthy Schools team of school

staff complete the Healthy Schools Program Assessment,<sup>35</sup> which is a version of the School Health Index that addresses health topics in the Healthy Schools Program Framework of Best Practices: Policy & Environment, Nutrition Services, Smart Snacks, Health & Physical Education, Physical Activity and Employee Wellness.<sup>35</sup> UPMC Children's provided the Autumn 2019 Healthy Schools Program Assessment data for our sample of schools. We then created School Health Index (SHI) scores by summing the number of items within each of the six domains that the school reported implementing or conducting within each domain and overall.

### Learning Garden participation duration

Grow Pittsburgh Learning Gardens were implemented in our sample of schools in Autumn 2016 (two schools), Autumn 2017 (three schools), Spring 2017 (three schools), Spring 2019 (one school) and Autumn 2019 (two schools). Accordingly, we created a garden duration variable based on the number of semesters since treatment schools started their garden (range 0–6 semesters). Control schools were assigned a value of 0 and the schools that initiated their garden in Autumn 2019 were assigned a value of 1. Although the students in the Autumn 2019 implementation schools may not have been exposed to a full semester of the program, we considered this as a conservative approach to account for any exposure that they received.

### Administrative data

The Pittsburgh Public Schools (PPS) database provided our study with students' race/ethnicity and gender.

### Statistical analysis

We averaged the 2 days of dietary data for each individual student. We calculated descriptive statistics, including means and proportions for outcomes and covariates. We compared school and student characteristics with *t* tests (for continuous variables) or chi-squared tests (for categorical variables). To compare student outcomes in treatment classes versus control classes, we used either *t* tests (for continuous variables) or chi-squared tests (for categorical variables).

To assess whether wellness policies were associated with student dietary outcomes, we constructed regression models in a stepwise fashion. First, we estimated energy consumed (kcal) as the outcome in univariate linear regression models as a function of each school-level lunch policy variable and School Health Index topic (i.e., Nutrition Services, Smart Snacks, Health & Physical

Education), child-level student demographics (including age and gender) and SHI score by domain and overall score. We retained variables that were significantly ( $p < 0.05$ ) associated with energy intake for inclusion in multivariable models. We clustered models on class to account for observations within class may not be independent of each other.

To examine how the length of time the child's school had participated in the gardening program, we estimated each outcome as a function of garden age (in semesters), controlling for students' grade and SHI indices retained from the above. For these analyses, we did not cluster on class because the length of time a school had a garden was unique to each school and the classes in the sample were unique to school. All models that estimated associations with garden duration were linear regression models.

As a result of the large number of significance tests conducted in our analyses, we adjusted for multiple testing using the Benjamini–Hochberg approach to address the risk of inflated type I error.<sup>36</sup> All statistical analyses were conducted using Stata, version 15.1 (Stata Corporation, College Station, TX, USA).

### Sensitivity analysis

We recognise that students' dietary observations may not be independent within class. Students' consumption of foods and beverages during the lunch period may be influenced by the foods and beverages their classroom peers consumed. Although evidence suggests that peers' influence on children's and adolescents' dietary behaviours can be negative in that it increases the consumption of energy-dense nutritionally poor foods, the influence can also be positive.<sup>37</sup> To address potentially dependent observations at the same time as avoiding clustering on the exposure of garden duration, we calculated intraclass correlations for each outcome and adjusted our standard errors for design effects.<sup>38</sup>

## RESULTS

The schools in our sample were largely serving economically disadvantaged families and with students that were predominantly African American (Table 1). Our sample of students included 80 youths (94% of those recruited). For 21% of the sample, we were unable to link the child's information to the PPS database, and so they are missing race/ethnicity, gender and free or reduced-price meal eligibility. Most students were identified as eligible for free or reduced-price meals. Fifty-nine percent of students attended a treatment school. Among the students attending schools with a garden, most of the schools participated in the garden program for four semesters. School characteristics were similar between the treatment and control schools. However, student

TABLE 1 School and student characteristics

Characteristics	Control (No Learning Garden)	Treatment (Learning Garden)	Total	<i>p</i> value <sup>a</sup>
<b>Schools</b>				
Number of schools	6	11	17	
Percent economically disadvantaged, mean $\pm$ SD <sup>b</sup>	77.4% $\pm$ 9.7%	74.1% $\pm$ 16.9%	75.8% $\pm$ 13.6%	0.56
Students enrolled, mean $\pm$ SD	301.3% $\pm$ 51.8%	393.4% $\pm$ 208.9%	347.4% $\pm$ 156.1%	0.15
Percent students African American, mean $\pm$ SD	63.1% $\pm$ 19.8%	73.3% $\pm$ 15.0%	68.2% $\pm$ 18.0%	0.17
<b>Students</b>				
Number of students	47	33	80	
Race/ethnicity, <i>n</i> (%)				<0.001
African American	7 (14.9)	23 (69.7)	30 (37.5)	
Asian	0 (0.0)	2 (6.1)	2 (2.5)	
Hispanic	1 (2.1)	1 (3.0)	2 (2.5)	
Multi-racial	4 (8.5)	2 (6.1)	6 (7.5)	
White	15 (31.9)	4 (12.1)	19 (23.8)	
Missing	20 (42.6)	1 (3.0)	21 (26.3)	
Gender, <i>n</i> (%)				<0.001
Female	13 (27.7)	18 (54.6)	31 (38.8)	
Male	14 (29.8)	14 (42.4)	28 (35.0)	
Missing	20 (42.6)	1 (3.0)	21 (26.3)	
Free or reduced-price lunch eligibility, <i>n</i> (%)				<0.001
Free lunch	20 (42.6)	24 (72.7)	44 (55.0)	
Reduced price lunch	7 (14.9)	8 (24.2)	15 (18.8)	
Missing	20 (42.6)	1 (3.0)	21 (26.3)	
Grade, <i>n</i> (%)				0.16
1st	15 (31.9)	8 (24.2)	23 (28.8)	
2nd	11 (23.4)	15 (45.5)	26 (32.5)	
6th	5 (10.6)	4 (12.1)	9 (11.3)	
7th	16 (34.0)	6 (18.2)	22 (27.5)	
Semesters of garden participation, <i>n</i> (%)				<0.001
0	47 (100.0)	NA	47 (58.8)	
3	NA	4 (12.1)	4 (12.1)	
4	NA	21 (63.6)	21 (63.6)	
6	NA	8 (24.2)	8 (24.2)	

<sup>a</sup>*t* tests (for continuous variables) or chi-square tests (for categorical variables).

<sup>b</sup>The percentage of students within a school who are considered "Direct Certified", receiving services through Temporary Assistance for Needy Families (TANF), Medicaid or Food Assistance.

characteristics differed between the groups likely because of the missing data and by variable design (e.g., semesters of garden participation).

On average, students selected foods and beverages with about 700 kcal, of which they consumed 428 kcal and threw

away 273 kcal during lunch, which was similar across students attending treatment and control schools (Table 2). Students consumed a little less than a cup of dairy and about 335 mg of calcium. They also consumed slightly more fruit than either vegetables or whole grains. Students

TABLE 2 Nutrients and food groups from students' school lunch consumption by Learning Garden participation

Nutrient/food group	Overall ( <i>n</i> = 80), mean ± SD	Control (No Learning Garden, <i>n</i> = 47), mean ± SD	Treatment (Learning Garden, <i>n</i> = 33), mean ± SD	<i>p</i> value <sup>a</sup>
Fruit (g)	76.5 ± 102.0	76.5 ± 76.5	76.5 ± 127.5	0.2
Vegetables (g)	36.4 ± 54.6	18.2 ± 36.4	36.4 ± 72.8	0.06
Whole grains (g)	5.6 ± 5.6	1.1 ± 4.5	4.5 ± 6.7	0.004
Dairy (g)	196.0 ± 147.0	220.5 ± 171.5	147.0 ± 122.5	0.004
Added sugars (g)	14.7 ± 15.5	15.5 ± 13.9	13.9 ± 17.2	0.56
Calcium (mg)	334.6 ± 214.0	364.2 ± 229.6	294.2 ± 184.9	0.05
Food consumption				
Food selected (kcal)	701.1 ± 266.4	670.9 ± 193.9	742.2 ± 338.7	0.11
Food waste (kcal)	273.0 ± 227.1	259.0 ± 207.9	292.0 ± 251.5	0.39
Food consumed (kcal)	428.0 ± 260.0	411.8 ± 229.2	449.9 ± 296.6	0.39

<sup>a</sup>Unadjusted *t* tests.

TABLE 3 School Health Indices (SHI) by schools' Learning Garden participation

Policy topic	Overall ( <i>n</i> = 17), mean ± SD	Control (No Learning Garden, <i>n</i> = 6), mean ± SD	Treatment (Learning Garden, <i>n</i> = 11), mean ± SD	<i>p</i> value <sup>a</sup>
Policy and environment	22.6 ± 3.4	23.5 ± 3.9	22.1 ± 3.9	0.44
Nutrition services	27.1 ± 3.6	25.8 ± 3.4	27.8 ± 3.7	0.30
Smart snacks	15.4 ± 4.2	13.0 ± 4.5	16.6 ± 3.6	0.09
Health and physical education	28.7 ± 2.9	28.0 ± 3.3	29.1 ± 2.8	0.48
Physical activity	13.7 ± 4.6	10.3 ± 3.1	15.5 ± 4.3	0.02
Employee wellness	13.2 ± 4.9	8.8 ± 5.3	15.6 ± 2.5	0.003
Sum of policies	120.8 ± 18.6	109.5 ± 29.3	126.8 ± 15.8	0.06

<sup>a</sup>Unadjusted *t* tests.

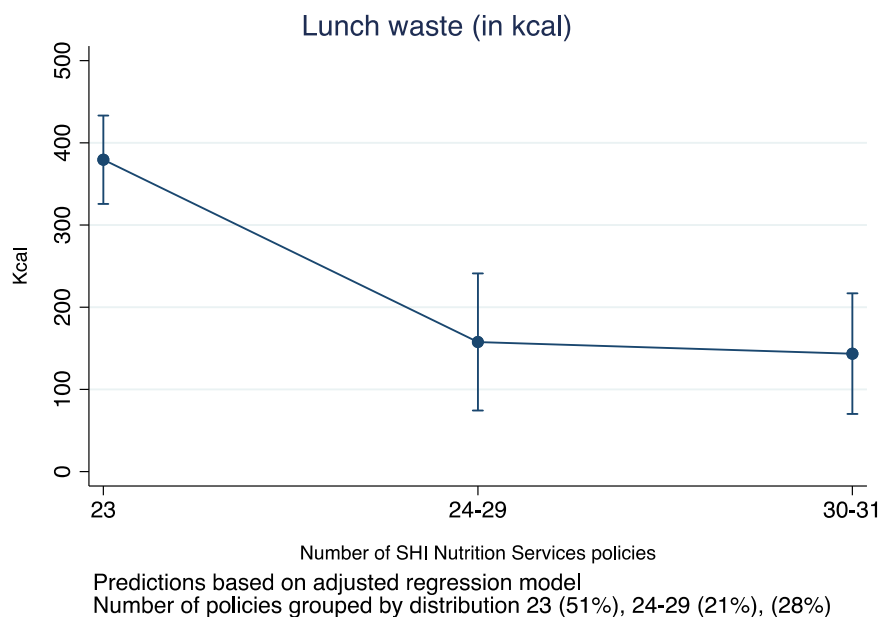
attending treatment schools consumed more whole grains than students attending control schools. However, the students attending treatment schools were consuming less dairy than their peers attending control schools.

Based on the Healthy Schools Assessment, schools participating in the study had adopted a variety of school wellness-related policies. On average, schools reported that they had adopted about 29 different types of Health & Physical Education policies, which was the most common category of policy topics (Table 3). Nutrition Services policies were the second most common policy type reported. Examples of Nutrition Services policies include promoting healthy food and beverages, prohibiting using food as a reward and not allowing withholding food as punishment. Although Physical Activity and Employee Wellness were the least common categories of policies, schools participating in Learning Garden programming reported having more Physical Activity ( $p = 0.02$ ) and Employee Wellness policies ( $p = 0.003$ ).

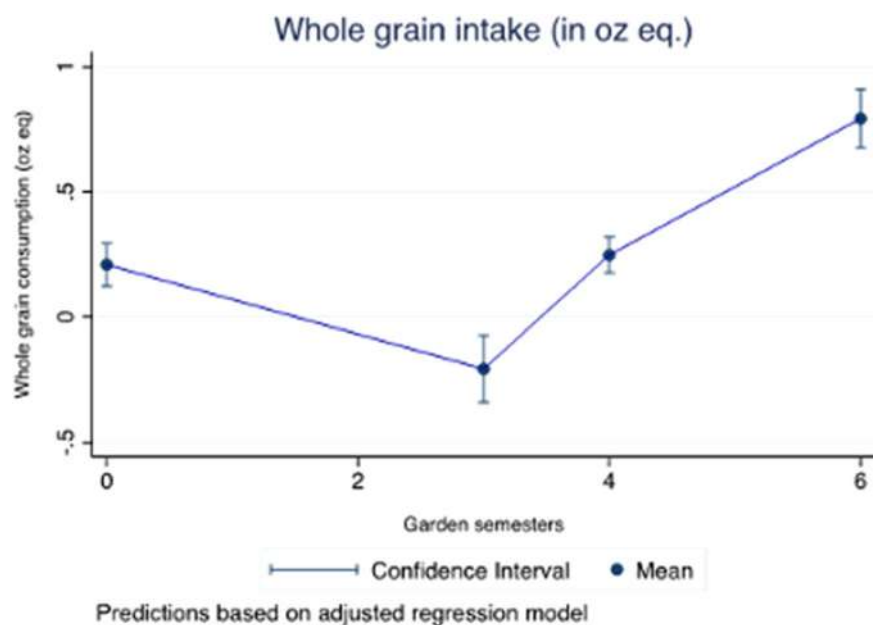
To identify significant associations with potential confounders, we estimated univariate models for demographics (gender, race/ethnicity and grade) and each SHI policy topic. From these analyses, grade and the total number of Nutrition Services policies were significantly associated with students' energy intake. As a result, we included these as covariates in our adjusted models predicting food consumption/waste.

In fully adjusted models, the number of SHI Nutrition Services policies was positively associated with calcium ( $\beta = 18.0$ ,  $p = 0.03$ ), whole grain ( $\beta = 0.1$ ,  $p = 0.01$ ) and added sugar ( $\beta = 0.2$ ,  $p = 0.04$ ) consumption, and negatively associated with energy wasted from lunch ( $\beta = -44.7$ ,  $p = 0.01$ ) (see Supporting information, Table S1). However, after correcting for multiple testing, the only association's *p* value that met the significance criteria was for energy waste. To illustrate the plate waste finding, the predicted energy wasted when students' schools had more than 23 SHI Nutrition Services policies





**FIGURE 1** Number of School Health Index (SHI) Nutrition Services policies and lunch consumption/waste.



**FIGURE 2** Garden duration and lunch consumption.

decreased by about 200 kcal and was similar for students whose schools had up to 31 policies (Figure 1).

The number of semesters the students' school had participated in the Learning Garden program was positively associated with student vegetable ( $\beta = 0.03, p = 0.02$ ) and whole grain ( $\beta = 0.07, p < 0.001$ ) consumption (see Supporting information, Table S2). However, the  $p$  value for association between garden semesters and vegetable consumption was larger than the significance criteria ( $p = 0.023$  vs.  $p = 0.014$ ) after multiple testing adjustment. Among students at schools with six semesters of Learning Garden participation, whole grain intake was estimated to be 0.5 oz (~14 g) equivalents greater than for students at schools with no garden program (Figure 2).

## Sensitivity analysis

The intraclass correlation for vegetable consumption was 0.40, which resulted in a design effect of 2.39. After adjusting the standard errors of the garden duration's association, the  $p$  value was  $p = 0.21$ . The intraclass correlation for whole grain consumption was 0.39, the design effect was 2.36 and the adjusted the estimated association was  $\beta = 0.03, p = 0.003$ . By accounting for the potential within classroom correlation, the association between garden duration and vegetable consumption was no longer significant; however, the association with wholegrain consumption remained significant.

## DISCUSSION

We found that students' dietary consumption differed between schools depending on the degree to which the school implemented nutrition services policies and the length of time that the school had participated in garden programming. Specifically, the students in our sample who attended schools with more semesters of garden programming consumed slightly more whole grains. Students attending schools that had implemented more nutrition services policies threw away less food than students from other schools. The plate waste findings may suggest benefits to children and schools, although it is important to consider that the higher average intake of about 200 kcal in one meal may increase the risk for obesity for students at schools with these policies. Future work should aim to better understand the quantity and quality of the foods and beverages that students consume depending on the school environments generated by their policies and programming. Also, metrics are needed to interpret relative intakes among children, such as evaluating energy intake data in relation to the energy needs of the child at a healthy weight.

### Implications for school health policy, practice and equity

Children continue to experience obesity despite major efforts to address it, especially in low-income populations.<sup>39</sup> This study was motivated by the goal of understanding how school environments could improve children's dietary behaviours and reduce their risk of obesity. Given that children spend more time at school than any other place when they are not at home, and school is where children can consume between 19% and 50% of their daily calories,<sup>1</sup> schools are key to increasing access to healthy foods, as well as to promoting children's healthy behaviours and well-being.<sup>2,3</sup>

The schools in our study had been participating in the Alliance for a Healthier Generation's HSP<sup>34</sup> since 2016 but the number and types of policies varied across schools. This suggests that, despite the evidence-based technical assistance integral to HSP, some schools may still face barriers to HSP adoption, whereas others may have resources (e.g., champions) that facilitate policy development and adoption. Overall, our findings are consistent with prior research that demonstrates how school wellness policies can increase school meal consumption and intake of nutritious foods<sup>40,41</sup> and reduce waste.<sup>42</sup> For example, two cluster randomised control trials found that modifying the cafeteria environment resulted in significant improvements to children's nutrition.<sup>41</sup> The intervention involved encouraging appropriate portion sizes, calories, and nutrient content of school lunches, recipe and portion changes, as well as posters, handouts and materials that promoted nutrition

goals. Despite mixed findings that are largely a result of measurement issues and policy implementation challenges, overall school policies that increase access to healthy foods may improve children's dietary intakes.<sup>43</sup>

Our study supports the studies reporting that robust school-based interventions can enhance children's food choices when they are in school.<sup>40–42</sup> Nonetheless, much of the broader literature shows that parents and the home environment have a much stronger influence than schools.<sup>44,45</sup> As such, school interventions that do not involve the family may have little impact on overall food choice, thereby providing limited means to prevent obesity and children's development of unhealthy food preferences. Indeed, increasing evidence suggests that effective strategies to prevent childhood obesity are multipronged and include family involvement.<sup>46–48</sup>

The evidence regarding school garden programming on children's dietary behaviours is mixed.<sup>20</sup> Here, the literature is largely limited by small samples and self-reported dietary outcomes. However, a systematic review identified 10 of 14 studies that found a small suggestive nutritional benefit to children after participating in a gardening intervention.<sup>20</sup> We found evidence that students' whole grain consumption at school differed across schools depending on the length of time that the school had a Learning Garden. In this descriptive study, we cannot separate schools' engagement in garden programming and HSP from other unobserved factors that would underlie why schools select into programs and policies. For example, we learned anecdotally that, in some schools, it was the principal who had championed the creation of their Learning Garden, whereas in others it was a teacher. On the other hand, lack of time for staff to use the garden was a noted challenge. Understanding how to support schools so they can foster environments that promote student health at the same time as recognising differences across school resources, climates and cultures is needed.

Capturing how modifying school environments may change students' dietary consumption requires accurate dietary measurement. Although children's nutritional intakes are paramount, waste is costly and can represent inefficient operations or unresponsive delivery processes. Future work is needed to reduce waste at the same time as increasing the nutritional quality of children's school lunch consumption.

### Limitations

The present study has limitations. The COVID-19 pandemic prevented us from completing our study as originally designed and our study is based on one public school district in Pittsburgh. Thus, our descriptive study is cross-sectional, and the results should not be considered causal. Furthermore, our findings may not generalise to other settings and unobservable child and

school characteristics may have confounded our results. In addition, because of the non-random selection into garden participation, our study is vulnerable to selection bias. Thus, participating schools may differ from non-participating schools in ways that would account for some or all of the associations that we observed. Moreover, the semesters of garden duration are at the school level, whereas the outcomes were at the student level. We do not know how much exposure the students had to the program. However, despite these limitations, we used robust and rigorous methods to collect rich dietary outcome data, including nutrients, food groups (e.g., vegetables) and waste. Furthermore, we were able to account for multiple aspects of school environments and policies.

## CONCLUSIONS

School programming that can increase the nutritional quality of children's dietary consumption is critical and should be expanded. Although school garden programming and policies may each contribute to improving children's diets, future work should explore how schools that engage in such programs and policies differ, what barriers hinder participation, and how to identify and support facilitators. In sum, the cross-sectional findings from our study support future research into the benefits of school environments that may include garden programs and school wellness policies.

## AUTHOR CONTRIBUTIONS

AN collected the data. ASR wrote the first draft with contributions from AN. All authors reviewed and commented on subsequent drafts of the manuscript.

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## CONFLICTS OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## ETHICAL APPROVAL

RAND's Human Subjects Protections Committee reviewed and approved all components of this study.

## PEER REVIEW

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### SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Impact and evaluation of an online culinary nutrition course for health, education and industry professionals to promote vegetable knowledge and consumption

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## Abstract

**Background:** Poor diet, including inadequate vegetable intake, is a leading risk factor for noncommunicable disease. Culinary and nutrition education provided to trainee and practising health and education professionals is an emerging strategy to promote improved dietary intake, including vegetable consumption. We evaluated the impact and feasibility of an online culinary medicine and nutrition (CM/CN) short course for health, education and vegetable industry professionals. The course aimed to improve participants' skills and confidence to prepare vegetables, knowledge of evidence-based nutrition information and recommendations for improving vegetable consumption and diet quality.

**Methods:** A pre–post study consisting of two separate groups participating in two course rounds recruited practising professionals ( $n = 30$ ) working in health; community, adult and/or culinary education; and the vegetable industry. Evaluation assessed diet quality, vegetable consumption barriers, cooking and food skill confidence, nutrition knowledge and process measures.

**Results:** Seventeen participants (68%) completed the programme. Pre- to postintervention statistically significant increases in vegetables ( $M 1.3$ ,  $SD 2.2$ ), fruit ( $M 1.6$ ,  $SD 3.1$ ), and breads and cereal ( $M 1.1$ ,  $SD 1.7$ ) intakes were observed. Statistically significant increases and large effect sizes for mean food skill confidence scores ( $M 8.9$ ,  $SD 15.4$ , Cohen's  $d 0.56$ ) and nutrition knowledge scores ( $M 6.2$ ,  $SD 15.4$ , Cohen's  $d 0.83$ ) were also observed pre- to postintervention.

**Conclusions:** The short online course was feasible and improved diet quality, food skill confidence and nutrition knowledge. Online CM/CN education for practising professionals represents a promising area of research. Future research involving a larger study sample and a more rigorous study design such as a randomised control trial is warranted.

## KEYWORDS

continuing professional development, cooking education, culinary medicine, culinary nutrition, online culinary education, vegetables

## Key points

- The online asynchronous course was feasible to run and well received by health, education and vegetable industry professionals.

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- After completing the 5-week online culinary nutrition course, participants had increased vegetable intake, bread and cereal intake, food skill confidence and nutrition knowledge.
- Findings indicate larger studies, with randomised control trial design, and that examine the impact on professionals' patients, clients and students are warranted.

## INTRODUCTION

Inadequate intake of vegetables, fruits and wholegrains and excess intake of energy-dense, nutrient-poor foods such as sugar sweetened beverages, lollies and take away foods are leading risk factors for noncommunicable diseases, including cardiovascular disease, diabetes and some cancers.<sup>1,2</sup> Low vegetable intake and variety has been shown to contribute to health burden,<sup>3,4</sup> with estimates showing that in Australia a 10% increase in vegetable consumption would have reduced cardiovascular disease and some cancers in 2015/16 resulting in reduced healthcare expenditure of AUD\$99.9 million.<sup>4</sup>

Higher-level cooking skills and more frequent home cooking is associated with increased vegetable intake and higher diet quality.<sup>5-7</sup> Culinary nutrition (CN) promotes healthy sustainable dietary patterns by incorporating nutrition practice, food science and culinary arts.<sup>8</sup> CN interventions have been shown to improve diet-related health and improve fruit and/or vegetable intake, knowledge, skill and confidence in cooking.<sup>9,10</sup> The use of practical instruction instead of theory or demonstration in culinary education has been identified as a more effective education strategy for long-term behaviour change.<sup>11</sup> Online CN education<sup>12-15</sup> and online training of education professionals to deliver CN programmes<sup>16</sup> are becoming increasingly popular, particularly during the COVID-19 pandemic. It is important that the information and skills taught are consistent with evidence-based nutrition recommendations. Evaluation of effectiveness of online CN interventions in modifying dietary and health-related outcomes is limited to only a few studies.<sup>14-16</sup>

Health professionals are in a position to provide nutrition information to support health promotion,<sup>17,18</sup> and should have an understanding of the importance of supporting behaviour change.<sup>19</sup> However, currently there is limited provision of nutrition education in undergraduate medical curricular,<sup>20</sup> and medical practitioners report a lack of training in regard to providing evidence-based nutrition advice within medical practice.<sup>21</sup> Providing nutrition training to healthcare providers is therefore an important strategy to help prepare them for helping patients address modifiable diet-related risk factors for chronic disease.<sup>21,22</sup> Culinary medicine (CM) offers a culinary focused, evidenced-based, practical and patient-centred approach to the prevention and management of diet-related chronic disease.<sup>23</sup> CM education programmes

equip healthcare providers with the skills and knowledge to promote culinary and diet-related health behaviour change in their patients or clients, while simultaneously promoting health behaviour change in the healthcare provider themselves.<sup>23,24</sup>

CM education primarily targets student and trainee medical practitioners,<sup>25</sup> however, practising health professionals from a range of health disciplines may also benefit as a form of continuing professional development (CPD). CPD for practising healthcare professionals that can be delivered remotely using technology such as video-conferencing and online courses can benefit professionals living in diverse locations, and represent feasible alternatives to traditional face-to-face or classroom-style learning. However, there is a need for more detailed and rigorous evaluation of the impact on learning outcomes and professional practice.<sup>26</sup> Teaching professionals with training in culinary arts, who teach in community education settings, may also benefit from CN education. This has a dual purpose of potentially impacting the professional's own behaviour through the provision of CPD on evidence-based, nutrition-related health promotion and also potential impacts on the dietary-related behaviours of their students. A scoping review by Asher et al. noted limited descriptions of CN training to facilitators to deliver CN interventions in community and adult education settings.<sup>25</sup> Therefore, there is the opportunity to target CN education to not only healthcare providers but also to culinary and nutrition education professionals in community and adult education settings to improve the reach of these programmes.

No studies have trialled CN courses for vegetable industry professionals. However, vegetable industry professionals have knowledge and expertise in vegetable growing, varieties and culinary uses as well as frequent contact with workers along the vegetable supply chain and the general public. Therefore, they have opportunities to promote vegetable consumption but may not have formal, in-depth nutrition education or culinary training required to support others. Research including vegetable industry professionals is needed.

The primary aim of the current study was to develop, deliver and evaluate the impact and feasibility of an online CM/CN short course for healthcare, education and vegetable industry professionals. The course was designed to improve their skills, knowledge and confidence to prepare vegetables, knowledge of evidence-based information and

recommendations for vegetable consumption, and dietary intake. The secondary aim was to address and further explore barriers to vegetable consumption among healthcare, education and vegetable industry professionals.

## METHODS

### Study design

The study was guided by the Cook-Ed model for cooking programme planning, implementation and evaluation.<sup>27</sup> Formative research included a scoping review examining the evidence related to CN education provided to health and education professionals.<sup>25</sup> A cross-sectional survey of healthcare and education professionals and their current cooking and food skills, nutrition knowledge, vegetable intake and variety, and barriers to provision of behaviour change education to clients, students and patients was also conducted and has been published elsewhere.<sup>28</sup> Findings from this formative research informed the development of a five-module, online, asynchronous instructor-led CM/CN short course.

Evaluation was conducted as a pre–post study over two programme rounds with two separate groups. Surveys were completed online (Qualtrics LLC) at baseline and postprogramme. Preprogramme surveys were completed in November 2020 (Group 1) and February 2021 (Group 2). Postprogramme surveys links were sent to participants on programme completion and had to be completed within 8 weeks of commencing the course. Postprogramme surveys were completed in December 2020–January 2021 (Group 1) and April 2021 (Group 2). Sample size was pragmatic due to time, budget and COVID-19-related constraints, and to enable meaningful engagement of programme interventionist (RCA) within the online discussion forums and live Q&A sessions.

### Participants and recruitment

Eligible participants included healthcare workers who saw clients/patients face to face; education professionals who worked in community nutrition, adult nutrition or culinary education; and vegetable industry professionals. Practising healthcare professionals from any health discipline and community-based or professional CN educators may benefit from CPD targeting CN education and were therefore included. Culinary education professionals were targeted as they may not have the necessary nutrition knowledge or skills, yet have opportunities to promote healthy culinary skill development through culinary education. Vegetable industry professionals were eligible due to access to these professionals via convenience sampling and their opportunity to promote vegetable consumption, but may not have formal,

in-depth nutrition education or culinary training required to support others.

Additional eligibility criteria included access to the internet; English speaking; access to a working kitchen including refrigeration, a stove top and oven; kitchen utensils including a minimum of one saucepan and/or frypan, a stirring utensil, cutting board and knife, mixing bowl and serving plate. Exclusion criteria included being <18 years of age and prior course completion.

Participants were recruited using convenience sampling through advertising the study via email, word of mouth and internal communication through the University of Newcastle and via networks of the University of Newcastle research team and Rijk Zwaan Australia Pty Ltd. Recruitment opened 3 weeks prior to each of the two programme groups commencing mid-November 2020 and mid-January 2021.

### Course content

Course content was guided by formative research.<sup>25,28</sup> Following the Cook-Ed model planning Stage 1 ‘Define the cooking related need or problem’<sup>27</sup> the programme goal was to emphasise different vegetable preparation and cookery methods, for a variety of vegetables, due to inadequate intakes in the Australian population<sup>1</sup> and the known health benefits related to increased vegetable intakes<sup>2</sup> and variety.<sup>3</sup> Formative research, course development and delivery were conducted in collaboration with vegetable industry experts (F. T. and J. B.; see acknowledgements and author S. R. who were not study participants) given their knowledge and expertise in vegetable growing, selection, storage and preparation.

Following Stage 2 of the Cook-Ed model ‘Consider behaviour change factors’,<sup>27</sup> factors that may influence culinary practices of health and education professionals were explored using a cross-sectional survey<sup>28</sup> with findings used to inform course content.

In the Cook-Ed model Stage 3 ‘Capacity Assessment’,<sup>27</sup> and with consideration to the COVID-19 pandemic, an online course was developed.

Guided by Cook-Ed model Stage 4 ‘Develop programme content and facilitation guides’<sup>27</sup> course content was created in partnership with vegetable industry experts (F. T., J. B. and S. R.), research team members with experience in CN education (R. C. A., T. B., V. A. S. and C. E. C.), consumer behaviour (T. B.) and a qualified chef (R. C. A.).

Over the entire course, cooking activities were designed to demonstrate vegetable-based dishes that could be used for each typical western-style diet eating occasion (i.e., breakfast, lunch and dinner and side dishes, and snacks). Vegetable-related food preparation, cooking and food skills reported by health and education professionals as having lowest confidence were prioritised for inclusion.<sup>28</sup> These included ‘making sauces and gravy from scratch’

which led to the inclusion of a number of cooking activities using vegetable-based sauces, ‘using vegetables as snacks’, and ‘buying food in season’ of which education for selection and use was emphasised through the ‘vegetable butchery’ videos. Low confidence scores for nonvegetable-related cooking or food skills (e.g., ‘baking cakes/bread/buns’) were not prioritised as teaching these skills did not meet the objectives of the course. Home learning cooking activities were linked to nutrition education presentations, ‘vegetable butchery’ and cooking demonstration videos, a weekly discussion board, live Q&A sessions, test your knowledge questions and further reading suggestions (Figure 1).

Nutrition education content was informed by findings of the health and education professionals survey.<sup>28</sup> Nutrition education on ‘special vs “fad” diets’, ‘simple vegetable recipes for meals, sides, snacks’, ‘using limited ingredients or utilising leftovers’, ‘identifying healthy portion sizes’, ‘creating balanced meals’ and ‘understanding food labels’ was prioritised for inclusion based on survey findings.<sup>28</sup> Although ‘cooking for different cultural groups’ was a highly requested topic, it was not possible to include it within the time constraints of the programme. Although health behaviour change counselling was reported as a barrier to providing nutrition education in practice<sup>28</sup> and a requested topic, it was not within the scope of the current CM/CN programme. Instead, participants were directed to an online open course specifically designed to support nutrition communication skills for behaviour change (nutrition communication for health professionals: key concepts and applying skills)<sup>55,56</sup> which was available online at that time.

All course material was provided through Blackboard Open Education Platform (Blackboard Inc.). A new module was released weekly over the 5 weeks, which participants could complete in their own time, with each module expected to take between 2 and 3 h. Announcements were made via Blackboard to alert participants to

new content, any upcoming live Q&A sessions and the release of postintervention surveys.

## Data collection and tool development

Existing validated tools were used to measure diet quality,<sup>29</sup> cooking and food skill confidence<sup>30</sup> and nutrition knowledge.<sup>31</sup> Barriers to vegetable consumption were measured by adapting questions from a previous survey on vegetable preparation and cooking barriers among individuals living in low-income households.<sup>32</sup>

## Diet quality

The Australian Recommended Food Score (ARFS) was used to measure diet quality and vegetable variety.<sup>29</sup> The ARFS has been validated previously in adults and has significant associations with a more comprehensive food frequency questionnaire.<sup>33</sup> The food frequency questionnaire and ARFS both are significantly correlated with plasma carotenoids.<sup>29,33,34</sup> The ARFS consists of 70-questions to assess usual intake, scores range from 0 to 73. Points are scored for intake of the following: vegetables (21); fruit (12); meat-based protein foods (7); vegetable protein foods (6); breads and cereals (13); dairy (11); water (1); spreads/sauces (2); additional points are scored for consuming vegetables  $\geq 5$  nights/week (1); choosing multigrain or wholemeal breads (1); and choosing reduced fat/skim or soy milk (1). Further details on ARFS have been published previously.<sup>29,34</sup>

## Barriers to vegetable consumption

Personal, interpersonal and environmental barriers to vegetable consumption were assessed by 13 questions

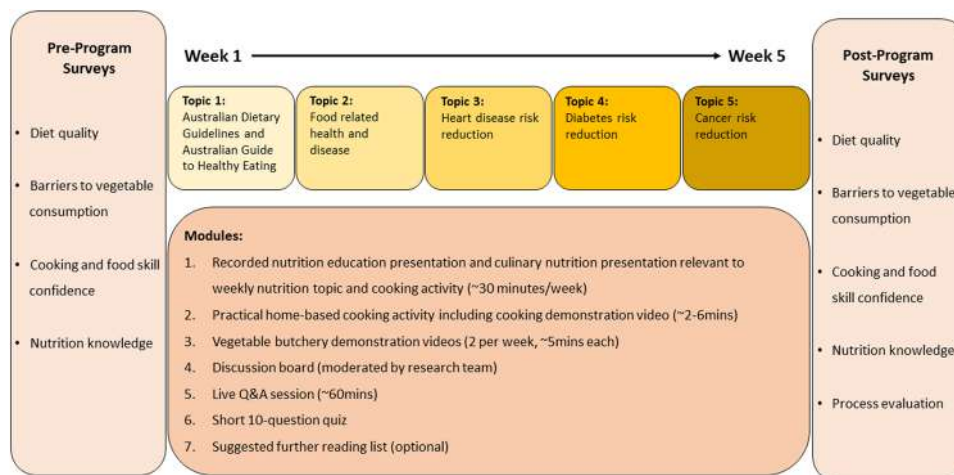


FIGURE 1 Summary of course topics, modules and programme structure



adapted from Landry et al.'s modified questionnaire<sup>32</sup> with a further 3 added regarding attitudes to eating and preparing vegetables to assess barriers to vegetable consumption identified in literature<sup>32,35–37</sup> and interventions designed to promote vegetable intake.<sup>38,39</sup> The additional questions were, 'I currently eat enough vegetables to meet my needs', 'I do not like to eat vegetables' and 'I do not like to prepare vegetables'. Questions related to availability of vegetables were asked on a four-point Likert scale (ranging from 1 = 'never' to 4 = 'all of the time'). Questions related to barriers to purchasing vegetables, barriers to preparing, cooking and eating vegetables, and attitude to eating and preparing vegetables were assessed using a five-point Likert scale (ranging from 1 = strongly disagree to 5 = strongly agree). Individual questionnaire items were summed and reported as a continuous variable.

### Cooking and food skill confidence

A validated 33-item questionnaire was used to measure cooking and food skill confidence.<sup>30</sup> Responses were measured on an eight-point Likert scale (ranging from 0 = never/rarely to 7 = very good). Cooking confidence measure scores were scored out of 98, and food skill confidence out of 147. To reflect study aims, an additional four questions were added. These included questions asking how often participants 'make a salad dressing', 'make a salad from scratch', 'use vegetables as snacks' and 'keep fresh vegetables for salads or side dishes'.

### Nutrition knowledge

Nutrition knowledge was measured using the validated 117-item, revised Australian nutrition knowledge questionnaire (AUS-R NKQ).<sup>31</sup> The AUS-R NKQ is made up of four sections: questions on dietary recommendations (19), nutrients in food (53), food choices (10) and diet–disease relationships (35). A total score of 117 is generated from questionnaire responses, with correct answers resulting in 1 point and incorrect or 'unsure' responses in 0 points.

### Process evaluation

At the completion of the programme, participants completed a 14-question survey designed to capture information on participant satisfaction and feedback. Participants responded to statements on a five-point Likert scale (ranging from 1 = strongly disagree to 5 = strongly agree). Statements were related to the ease of understanding the course ('The culinary nutrition short course was easy to understand'), and separate

statements were used to evaluate changes in quantity and variety of vegetable consumption and preparation and how participants discuss food and nutrition with their patients/clients as a result of the course. Participants were asked to indicate (tick all that apply) what components of the course (e.g., key reading, nutrition presentations, vegetable butchery videos) they found most beneficial, and which modules they found most beneficial (select up to three). Two questions evaluated how frequently they used the course and on average how much time they spent on the course. Participants were asked to indicate on a scale of 0 (not recommend) to 10 (strongly recommend) whether they would recommend the course to other professionals in their field. Two open-ended questions captured qualitative feedback on the programme by asking, 'Do you have any suggestions for how the researchers can improve the short course?' and 'Do you have any more comments about the short course that you think might be useful for the researchers?' Qualitative responses were summarised by a member of the research team (R. C. A.).

### Statistical analysis

STATA Statistical/Data Analysis software, version 15.1 (StataCorp) was used to conduct the statistical analysis. Data were checked to see if it was normally distributed. Continuous data were reported as mean (*M*) and standard deviation (*SD*). Categorical data were reported as frequencies. Preliminary efficacy to assess the changes in mean scores from pre to postintervention was analysed using paired *t*-tests. Cohen's *d* ( $(M1 - M2) / SD_{baseline}$ ) was used to estimate effect sizes. A Cohen's *d* > 0.5 indicated a medium and > 0.8 a large effect.<sup>40</sup> Independent *t*-tests were run to determine if there were any differences at baseline between completers and noncompleters. A sensitivity analysis was undertaken to include participants who did not complete the postprogramme survey. As data did not appear to be missing at random, last observation carried forward was used. Descriptive statistics and a thematic analysis were undertaken to report findings from the process evaluation.

## RESULTS

Thirty participants consented to participate in the programme (Group 1 *n* = 13; Group 2 *n* = 17). Five participants who registered and completed the preprogramme survey did not go on to enrol in the online course (Group 1 *n* = 1; Group 2 *n* = 4). Of the remaining 25 participants who enrolled, 17 (68%) participants completed the postprogramme survey (Group 1 *n* = 10; Group 2 *n* = 7). Of the eight participants who did not complete the postprogramme survey, only one participant was rated as an 'active participant' in the course,



TABLE 1 Summary of participant characteristics

Characteristics	<i>n</i>	%	<i>M</i>	<i>SD</i>
Community education	1	5.9		
Health professional	14	82.4		
Vegetable industry	2	11.8		
Female	15	88.2		
BMI	17	–	25.1	3.3
Age	17	–	44.6	12.9
<i>Meal provision</i>				
Most of the time	14	82		
Sometimes	1	5.9		
About half of the time	1	5.9		
Rarely	1	5.9		
Never	0	0		
<i>Employment status</i>				
Full time	8	47.1		
Part time	7	41.2		
Self-employed part time	2	11.8		
<i>Education</i>				
Postgraduate	6	35.3		
Bachelor's degree	10	58.9		
Trade certificate/diploma	1	5.9		
<i>Years practising</i>				
3–5 years	2	11.8		
5–10 years	4	23.5		
>10 years	11	64.1		
<i>Health discipline</i>				
Nursing	2	14.3		
Medical officer	3	21.4		
Physiotherapy	1	7.1		
Occupational therapy	3	21.4		
Dietitian	1	7.1		
Podiatry	1	7.1		
Dentistry	1	7.1		
Dental assistant or oral health	1	7.1		
Other (health promotion)	1	7.1		
<i>Health setting</i>				
Public hospital	6	42.9		
Private hospital	1	7.1		
Community health centre	3	21.4		
Private practice	4	28.6		

TABLE 1 (Continued)

Characteristics	<i>n</i>	%	<i>M</i>	<i>SD</i>
Other (not for profit, community outreach)	2	14.3		
<i>Interaction with patients/clients</i>				
Face to face with clients/patients	10	50		
Face to face with family/carer	5	25		
Small-group education (>8)	4	20		
Large-group education (>10)	1	5		
Average time spent with patients/clients (min)	17	–	37.9	25.1
Average number of patients/clients per week	17	–	30.5	33.4
<i>Cooking and food skill confidence scores</i>				
Cooking skill confidence	16	–	78.4	14.7
Food skill confidence	17	–	98.5	16.1

Note: BMI, body mass index; *M*, mean; *SD*, standard deviation.

defined as having engaged in either the discussion board, live Q&A session and/or 'test your knowledge' quiz in addition to other course content. Therefore, the primary data presented report results of the participants who completed both the pre- and postprogramme surveys.

## Participant characteristics

Of the 17 participants who completed the online programme the majority were health professionals ( $n = 14$ ), female ( $n = 15$ ), had been practising for >10 years ( $n = 11$ ) and were the primary person responsible for providing meals in their household ( $n = 14$ ) (Table 1). There were no significant differences in baseline characteristics between completers and noncompleters (Supporting Information Table 1).

## Diet quality (ARFS)

Table 2 summarises the overall diet quality and vegetable intakes pre- and postprogramme. Significant increases from preprogramme were observed for total diet quality as well as diet quality subscale scores for vegetables, fruit, breads and cereals, and spreads and sauces. The greatest effect sizes were observed for total diet quality (Cohen's  $d$  0.73) and the fruit subscale scores (Cohen's  $d$  0.68). The results of the sensitivity analysis also showed a significant increase from baseline for all the same variables, except fruit which was no longer significant. Effect sizes were much smaller, with none of the Cohen's  $d$  results showing a moderate effect (Supporting Information Table 2).

TABLE 2 Australian Recommended Food Score (ARFS) diet quality and diet quality subscale scores pre- and postprogramme

Outcome measure (maximum available score)	Baseline ( <i>n</i> = 17)		Postprogramme ( <i>n</i> = 17)		Mean difference (post–baseline)	Effect size (Cohen's <i>d</i> )
	<i>M</i>	SD	<i>M</i>	SD	<i>M</i>	
ARFS – vegetables (21 points)	15.5	2.7	16.8	2.7	1.3*	0.48
ARFS – fruit (12)	5.4	2.4	6.9	2.2	1.6*	0.68 <sup>a</sup>
ARFS – meat chicken, fish and seafood (7)	3.4	1.5	3.5	1.6	0.1	0.07
ARFS – nuts, eggs and vegetarian meat alternatives (6)	3.4	1.9	3.8	1.6	0.4	0.23
ARFS – breads and cereals (13)	5.4	2.3	6.5	2	1.1*	0.52 <sup>a</sup>
ARFS – milk, cheese and yogurt (11)	3.1	1.7	3.2	1.6	0.1	0.04
ARFS – water (1)	0.9	0.3	0.9	0.2	0.1	0.20
ARFS – spreads and sauces (2) <sup>b</sup>	0.2	0.4	0.5	0.6	0.3*	0.55 <sup>a</sup>
Total score (73)	37.3	6.7	42.2	6.9	4.9**	0.73 <sup>a</sup>

Note: *M*, mean; SD, standard deviation. \*\*\**p* < 0.001.

<sup>a</sup>Cohen's *d* > 0.5 indicating medium effect.

<sup>b</sup>Spreads and sauces, including yeast extract spread, tomato ketchup/barbecue sauce, contribute a large amount of B-group vitamins or β-carotene, respectively; therefore, they are included in the ARFS scoring.<sup>57</sup>

\**p* < 0.05; \*\**p* < 0.01.

## Barriers to vegetable consumption

Table 3 summarises participants' barriers to vegetable consumption. The only statistically significant finding was an increase in agreement with the statement 'I currently eat enough vegetables to meet my needs' from pre- to postprogramme. This remained significant in the sensitivity analysis including all 30 participants; however, the effect size was reduced (Supporting Information Table 3).

## Cooking skill confidence and food skill confidence scores

Cooking skill confidence did not increase significantly from pre- (*M* = 78.4, SD = 14.7) to postprogramme (*M* = 79.1, SD = 13.9). Food skill confidence scores, however, showed a significant increase in participants who 'use vegetables as snacks' (*M* = 1.2, SD = 0.5, *p* < 0.01; Cohen's *d* 0.9) and for total food skill confidence score (*M* = 8.9, SD = 15.4, *p* < 0.05; Cohen's *d* 0.56). These findings remained significant in the sensitivity analysis; however, effect sizes were reduced (Supporting Information Table 4).

## Nutrition knowledge (AUS-R NKQ)

Total nutrition knowledge (*M* = 6.2, SD = 6.3; Cohen's *d* 0.83) and diet–disease relationship subscale (*M* = 2.7, SD = 2.5; Cohen's *d* 0.93) scores significantly increased from pre- to postprogramme. Moderate effect sizes for

nutrition knowledge subscales dietary recommendations (Cohen's *d* 0.64) and nutrients in food (Cohen's *d* 0.55) were also noted even though changes were not statistically significant. In the sensitivity analysis none of these findings remained significant (Supporting Information Tables 5 and 6).

## Participant engagement and acceptability of the programme

Programme satisfaction is reported in Figure 2. Briefly, the majority (*n* = 15) of participants who completed the online programme agreed or strongly agreed that the programme encouraged them to eat a greater quantity and variety of vegetables. Similarly, the majority of participants (*n* = 13) reported that the programme encouraged them to prepare a greater quantity and variety of vegetables at home. Nearly all participants agreed or strongly agreed that they were satisfied with the course (*n* = 16) and found the course easy to understand (*n* = 15).

When participants were asked how long they spent per week engaging with the course, participants reported spending 1–2 h (*n* = 12), 2–3 h (*n* = 4) and <30 min per week (*n* = 1). The top three most beneficial modules identified by participants were 'Food-related health and disease' (*n* = 10), 'Diabetes risk reduction' (*n* = 10) and 'Cardiovascular disease prevention' (*n* = 9), whereas the top three most beneficial components of the programme included the nutrition education presentations (*n* = 15, 88%), home-based cooking activity (*n* = 12) and the recipe presentations (*n* = 10).

TABLE 3 Self-reported barriers to vegetable consumption pre- and post-programme

Outcome measure	Baseline ( <i>n</i> = 17)		Postprogram ( <i>n</i> = 17)		Mean difference (post–baseline)	Effect size
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	(Cohen's <i>d</i> )
<i>What foods were available in your home last week?</i> <sup>a</sup>						
Fresh vegetables	3.9	0.4	3.9	0.3	-0.06	0.04
Canned, frozen or dried vegetables	3.4	1.0	3.4	1.0	-0.6	-0.01
Salad	3.7	0.7	3.7	0.5	-0.1	0.07
Cut up vegetables	2.4	1.2	2.6	1.1	0.5	0.18
<i>Do you experience any of the following challenges when buying vegetables for meals in your home?</i> <sup>b</sup>						
Vegetables are too expensive	1.8	0.6	1.9	0.9	0.1	0.08
I cannot find quality vegetables	2.0	0.9	2.3	1.1	0.3	0.29
The stores near me do not sell fresh vegetables	1.6	0.6	1.5	0.6	-0.1	-0.19
<i>Do you experience any of the following challenges when buying vegetables for meals in your home?</i> <sup>b</sup>						
It is hard to use vegetables before they spoil	2.5	0.9	2.6	0.9	0.1	0.13
My family/the people I cook for don't like vegetables	2.1	1.2	2.1	0.9	0.1	0.05
I do not have time to prepare vegetables	1.8	0.7	2.0	0.6	0.2	0.26
I do not know how to prepare vegetables	1.6	0.9	1.5	0.5	-0.1	-0.17
I do not have simple or quick recipes for vegetables	2	1.1	1.9	0.8	-0.1	-0.13
My family/ the people I cook for do not help me cook	2.4	1.0	2.4	1.0	-0.1	-0.06
I currently eat enough vegetables to meet my needs	3.2	1.3	4.0	1.0	0.8*	0.66 <sup>c</sup>
I do not like to eat vegetables	1.4	0.7	1.2	0.4	-0.2	-0.30
I do not like to prepare vegetables	1.6	0.7	1.8	1.0	0.2	0.21

Note: Items with a trend to reducing barriers (negative mean difference<sup>b</sup>) are highlighted in green.

<sup>a</sup>Scoring: 1 (never) to 4 (all of the time).

<sup>b</sup>Scoring: 1 (strongly disagree) to 5 (strongly agree).

<sup>c</sup>Cohen's *d* > 0.5 indicating medium effect.

\**p* < 0.05; \*\**p* < 0.01; \*\*\**p* < 0.001.

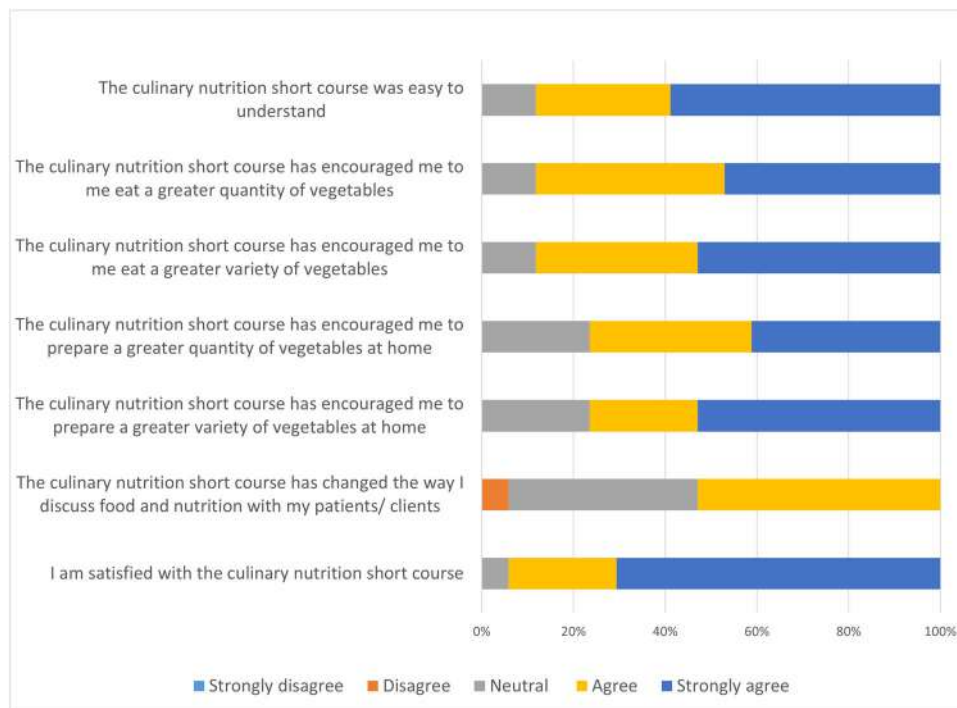


FIGURE 2 Participant satisfaction with the culinary nutrition course

Qualitative feedback was positive overall. The themes identified to help improve the programme were regarding changes to content delivery, for example, more use of summaries, handouts and highlighting key messages ( $n = 6$ ); visual presentation, for example, more pictures or diagrams in presentations and recipes ( $n = 4$ ); and course content, for example, complexity of information ( $n = 4$ ). Some participants indicated that the course had improved their confidence to speak with patients about nutrition ( $n = 2$ ) and changed their dietary and cooking behaviour to include more variety ( $n = 1$ ) and include the recipes used in the course ( $n = 1$ ). One participant found difficulty adapting the recipes to suit dietary requirements (FODMAPS) and the need to modify the food budget to incorporate the home cooking activity.

## DISCUSSION

The current study evaluated a 5-week online, asynchronous CM/CN CPD programme for health, education and vegetable industry professionals. Findings from the current study showed that the course resulted in positive improvements in participants' overall diet quality, with increased variety of vegetables, fruit, breads and cereals reported. Improvements in food skill confidence and nutrition knowledge were also reported. Overall, the course was well received by participants.

The current online CM/CN short course primarily enrolled health professionals, but also included some education and vegetable industry professionals. This is

not surprising given the recruitment strategy used existing networks and differences in CPD requirements between health, education and vegetable industry professionals.

The retention rate in the current study (68%) was similar to those of other CM/CN programs that moved to online mode due to COVID-19, which had retention rates ranging from 65% to 70%.<sup>14,15</sup> The retention rate is similar to a CM programme targeting practising medical professionals,<sup>41</sup> whereas a CM programme delivered to seven dually qualified health coaching and culinary professionals had a retention rate of 100%.<sup>42</sup> Previous online programs have shown that free online courses tend to have a large reduction from the number of participants who initially sign up versus those who complete the programme, with retention rates reported typically between 10% and 20%.<sup>12,43</sup> This suggests that people generally are interested in online programmes, but further incentives, such as obtaining CPD accreditation recognised by professional associations, may support improved retention in this population.

Significant improvements in diet quality, vegetable, fruit, and breads and cereals were observed in the current study. Baseline total ARFS, vegetable and vegetarian alternative subscales were higher than previously reported in the general population;<sup>44</sup> all other ARFS subscales were similar. Across the course, significant improvements in overall diet quality and the vegetable subscale were expected due to the primary target of improving vegetable intakes. Additional improvements in the fruit subscale among completers and breads and

cereals were also observed. These findings are similar to those of other CM/CN programmes which have also demonstrated improvements in vegetables, fruit and grain intakes.<sup>45–48</sup> Although larger and longer-term evaluations are still required, findings from the current study support previous conclusions that CM/CN programmes positively impact the diets of participants.<sup>9,10,25</sup>

Commonly reported barriers to vegetable consumption include taste, lack of time, knowledge or skills to prepare, cost and availability of vegetables in the home.<sup>32,35–37</sup> At baseline participants' scores indicated low barriers to vegetable intake. Results should be interpreted with caution as it is possible that those who participated in the current study may have more interest in vegetable intake and nutrition-related health. The low scores for barriers to vegetable intakes at baseline may explain why no significant changes in scores for barriers to vegetable intake were identified. However, although not statistically significant, there were trends to a further reduction in barriers postprogramme regarding access to cut up vegetables in the home, access to fresh vegetables at the store nearby, not knowing how to prepare vegetables, not having simple/quick recipes for vegetables and not liking vegetables. Previous interventions aimed at addressing barriers to vegetable consumption in the general population have been successful;<sup>38,39,49</sup> however, those interventions were targeted at different populations, mostly healthy adults. Larger studies are required to evaluate whether CM/CN programmes can be used to overcome health, education and vegetable industry professional barriers to vegetable intakes and increase intakes sufficiently to confer health gains.

Cooking skills and nutrition knowledge significantly improved in participants who completed the online course. Previous CM/CN programmes run for health professionals have also reported an improvement in nutrition skills and knowledge postprogramme.<sup>25</sup> In education professionals, it has been reported that a lack of nutrition knowledge is a barrier to supporting others under their care to make dietary changes.<sup>50</sup> To our knowledge the effect of CM/CN programmes on cooking skills and nutrition knowledge has not been examined previously in vegetable industry professionals. CM/CN programmes, such as the current course, can be used to improve cooking skills and nutrition knowledge in professionals working in roles with opportunity to influence the diets of others. Improving nutrition skills and knowledge in health, education and vegetable industry professionals is the first step to supporting these professionals to assisting their patients/clients and students to make dietary changes. Findings from the current CM/CN course reflect this notion, with a majority of participants agreeing or strongly agreeing that this course helped how they discussed nutrition with their patients/clients.

The current CM/CN course was well received by participants, with those who completed it reporting that

they found the course easy to understand and encouraged them to eat a greater quantity and variety of vegetables. To our knowledge this is the first CM/CN CPD course targeting health, education and vegetable industry professionals. More than half of participants reported that this course improved how they discussed food and nutrition with clients; although this was not the focus of the programme, the majority agreed with this statement. Future programmes could consider a module on how to discuss food and nutrition with their clients and patients. Considering the course was well received by participants, these results are promising for implementation and evaluation of future programmes, particularly with health professionals. However, larger interventions with a more heterogenous sample are still required to determine whether this applies to other professional groups such as those in education settings.

One of the strengths of the current study was that the online programme was run asynchronously; this allowed participants to access the course in their own time, and therefore this creates greater opportunities for CPD activities.<sup>51</sup> In addition, asynchronous online CM/CN programmes are cost effective and offer sustainable delivery methods which allows for scale-up opportunities. Lastly, validated assessment tools were used to assess nutrition knowledge, cooking and food skill confidence and diet quality, and previously tested questions to measure barriers to vegetable intake within the current study.<sup>29–32</sup> The use of validated measures has been lacking in other CM/CN programmes.<sup>9,10,25,52</sup> Limitations of the current study included that participants were recruited through convenience sampling, which may have resulted in selection bias, particularly because of the homogenous sample consisting of a high percentage of health professionals who hold postgraduate qualifications. Another limitation was that there was a higher-than-usual attrition rate (68%), particularly in Group 2 of the intervention ( $n=4$ , 80%). Potentially a greater drop-out rate in Group 2 occurred due to the timing of the programme for this group (early January–April 2021); in Australia this timing of course recruitment occurred around the main time of the year people take annual leave and course completion during a period of multiple public holidays. The timing of future courses should be considered to ensure greater impact. In addition, COVID-19 may have impacted the attrition rates as this programme was run during the pandemic. To account for these higher attrition rates last observation carried forward was applied to the analysis; however, one of the limitations of this approach is that it can underestimate the treatment effect, which was observed in the current study.<sup>53</sup> Finally, there was no behaviour change component in the current programme as it was not within the scope of the current programme. Improving an individual's skills and knowledge alone has been shown previously to not be the driver of long-term dietary change.<sup>54</sup> However, participants were directed to an online open course specifically designed to support nutrition



communication skills for behaviour change,<sup>55,56</sup> which were available online at the time.

Future research with larger samples sizes could consider longer-term follow-up to explore whether the dietary behaviours at the end of the programme are maintained. Creation of a CPD CM/CN programme that includes a behaviour change education component and evaluates the impact on practitioner's competency in nutrition counselling may be warranted. Further exploration of the impact on patients, clients and students counselled by trained practitioners may also be warranted.

## CONCLUSION

CM/CN programmes which provide practical culinary and nutrition education are an emerging strategy being used to provide nutrition, food and cooking skills training to health professionals. The need for larger, high-quality studies and more rigorous evaluation of these programmes in both health professional and other education and industry professionals is warranted.<sup>25</sup> Evaluation on the impact on their patients, clients and students would add further rigour. The current research provides evidence to support feasibility and acceptability of CM/CN programmes targeting vegetable consumption, and findings can be used to inform future programmes. Findings from the current study support that this short, asynchronous, online programme is feasible and can elicit desired changes in diet quality, food skill confidence and nutrition knowledge.

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## CONFLICT OF INTEREST

Steven Roberts is employee of Rijk Zwaan Australia. The rest of the authors declare no conflict of interest.

## ETHICS STATEMENT

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the University of Newcastle's Human Research Ethics Committee (approval number H-2020-0276). Written informed consent was obtained from all subjects/patients.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Investigating ‘treat culture’ in a secure care service: a study of inpatient NHS staff on their views and opinions on weight gain and treat giving for patients in a forensic secure care service

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## Abstract

**Background:** Obesity is a significant health inequality within forensic secure care mental health/learning disability inpatient settings. Patients may be at increased risk of developing preventable long-term conditions/premature death. This study investigated staff views on patient weight gain, how it affects patients and how to better manage patient weight in this setting. Furthermore, the research explored the culture of food being used as a ‘treat’ and the perceived impact of ‘treats’ on weight.

**Methods:** A two-phase mixed methods approach was taken to explore staff views on patient weight gain and the ‘treat’ culture on adult forensic secure care inpatient wards in one NHS Mental Health Trust in the north-east of England. Phase one was an online survey, and phase two consisted of semi-structured qualitative interviews. The quantitative survey data were analysed using descriptive statistics. Thematic analysis was used for the open-ended survey questions and interview data.

**Results:** The survey had 49 responses out of a possible 380 (13%). Ninety-two per cent of staff participants viewed patient weight gain as an area for concern, citing a range of reasons for weight gain. Weight gain was considered a risk to developing long-term health conditions and poor mental health. Nine participants were interviewed. Six themes were identified suggesting why patients might gain weight in forensic secure care, for example, patient history, staff behaviours, the surrounding ‘treat’ culture in this environment, along with suggestions of what could be improved to manage patient weight.

**Conclusions:** People detained in forensic secure care may be more at risk of weight gain due to their history, the secure care environment and the ‘treat’ culture adopted in these environments.

## KEYWORDS

forensic, learning disability, mental health, obesity, secure care, treat culture, treats

## Key points

- There are multiple components which contribute to patient weight gain.
- Staff are concerned about patient weight gain.
- People detained in secure care are more at risk of weight gain due to their history and the secure care environment.
- There is a complex ‘treat culture’ adopted in these environments.

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## INTRODUCTION

Forensic secure care services provide inpatient care for people with a mental health condition or learning disability who are currently undergoing, or have previously undergone, legal court proceedings and/or are deemed to be too high a risk of harming others.<sup>1</sup>

It is widely acknowledged that people living with a mental health condition are more likely to die earlier from preventable illnesses.<sup>2–5</sup> In England, 28% of adults are living with overweight/obesity.<sup>6</sup> This may be up to 40%–52% of people with a serious mental illness<sup>7</sup> contributing to a three times excess mortality rate compared to the general population, and a life expectancy 15–20 years lower.<sup>2,5</sup> A systemic review on obesity in adult mental health secure hospitals found that excess weight is more prevalent in this setting, with rates of up to 80% reported.<sup>8</sup> Public Health England (2017) (now Office for Health Improvement and Disparities [OHID]) recommended that organisations work together to improve the obesogenic environment (which encourages increased energy intake and decreased expenditure) in secure inpatient settings, for example, by addressing food policies and food provision, patient access to takeaways and shop product selection.<sup>8</sup> However, in practice there are barriers to healthcare staff restricting patients access to takeaways and snack foods due to the Care Quality Commissions' (CQC) stance on restrictive practice.<sup>9,10</sup> Furthermore, Public Health England (2021) provides guidance on managing a healthy weight in secure care,<sup>11</sup> offering practical suggestions on how to achieve an environment more conducive to managing a healthy weight.

It was observed by the lead author that there appeared to be a culture of 'treats' and 'treat-giving' among staff and visitors. The authors were unable to find existing research on 'treat' or 'treat-giving' to adults in mental health or forensic secure care settings. Current research on 'treats' and 'treat-giving' has mainly been conducted around treats given to children. McCafferty et al.<sup>12</sup> reported that treats were seen as 'energy-dense' and 'highly palatable' foods, and although these foods were acknowledged as unhealthy, parents perceived the treats to be infrequent and therefore easily justified.

The study aims were:

- i) to provide insights into the staff's opinions on patient weight gain,
- ii) to explore staff perceptions on how weight gain might affect the patient,
- iii) to investigate what might help to manage the patient's weight in forensic secure care,
- iv) to examine the culture of food being used as a 'treat' in forensic secure care inpatient settings, and
- v) to look at the perceived impact of 'treats' on patient weight gain.

This study focused on inpatient forensic secure care (low and medium security) for adult men with either a

learning disability (a significantly reduced ability to understand/interpret new or complex information and an inability to cope independently)<sup>13</sup> or a severe mental illness (e.g., schizophrenia, bipolar disorder, other psychoses or personality disorders).

## METHODS

This study used mixed methods to explore the 'treat-culture' used by staff members on adult forensic secure care inpatient wards in one NHS Mental Health Trust in the north-east of England. This study used a two-phase design: phase one was an online survey, and phase two consisted of semi-structured qualitative interviews with inpatient staff. Although there are likely multiple components to 'treat-culture', this study only explored that of inpatient staff. Further studies will need to be conducted to look at the impact of carers/visitors on 'treating' patients.

The survey was created using Cumbria, Northumberland, Tyne & Wear NHS Foundation Trust's in-house online survey platform (questionnaire creator V2) and consisted of 17 questions which were 'tick-box' and open-ended questions with space for free text (Appendix A). The questionnaire was piloted by a small cohort ( $n = 5$ ) of dietitians and subsequently adapted. The survey was sent electronically through the staff email system, via administration staff (gatekeeper), to all patient-facing staff (nurses, healthcare assistants, allied health professionals [AHPs], doctors, sports staff, sessional staff [e.g., woodwork]) who work with forensic secure care inpatients. Staff were able to complete the survey at a time and place suitable for them. The survey was sent to approximately 380 staff.

The survey was open for a 3-week period (3–24 June 2021), with weekly reminders being sent twice by the gatekeeper after the initial invitation email was sent.

The survey phase was anonymous, unless staff opted to leave their name and contact details (these were kept in a separate password-protected document) to express an interest in participating in a follow-up interview.

Phase two consisted of qualitative semi-structured interviews (Appendix B) remotely over Microsoft (MS) Teams. MS Teams was chosen due to COVID-19 restrictions; such platforms have been found to be suitable in previous studies for semi-structured interviews.<sup>14</sup> Purposive sampling<sup>15,16</sup> was used to recruit a range of professionals working into either forensic mental health (MH) or learning disability (LD) or both and proceeded until no further themes emerged.<sup>17,18</sup> Written consent was obtained prior to the interview, with further verbal consent at the start of the interview. The interviews lasted between 40 and 60 min and were recorded and transcribed by the interviewer. One interviewer (AA) worked as a dietitian for the forensic secure care service. Although the interviewer was an experienced dietitian, they were new to the forensic secure care service. The interviewer ensured that all questions remained open and endeavoured

to avoid leading questions. The interviewer was trained and supported by experienced qualitative researchers (EG and AAL). The transcriptions were fully transcribed, ad-verbatim using the video recording and transcription setting on MS Teams (by AA). The recordings were accessible only by the interviewer and participant and were deleted once transcribed.

## Data analysis

Descriptive statistics were used for the quantitative survey data. Thematic analysis was used for both the open-ended survey questions to analyse the interviews.<sup>19,20</sup> The interview transcripts were manually examined for commonalities and links. The transcripts were coded by AA and then grouped into common themes by the wider team (AA, JS and AAL) along with regular meetings to agree on a thematic framework. A final review of transcripts was conducted to ensure that information collected under each theme was accounted for and that no further themes presented.

Ethical approval was obtained via the Integrated Research Application System (IRAS: 291871), and the study was registered with the Health Research Authority (HRA). In addition, the study gained approval and sponsorship from the Research Department of Cumbria, Northumberland, Tyne and Wear NHS Foundation Trust.

## RESULTS

### Phase one: survey

Approximately 380 staff work directly with patients in secure care, and of those 13% ( $n = 49$ ) completed the online survey. A higher proportion of staff from the forensic secure care learning disability service (LD 63% [ $n = 31$ ]) completed the survey, than from the forensic secure care mental health (MH 20% [ $n = 10$ ]) wards and staff who cover both MH and LD sites: 16% ( $n = 8$ ).

A range of professionals completed the survey, with the most responses from AHPs. Most staff (30%) were aged between 36 and 45 years ( $n = 15$ ) and were women (59%) ( $n = 29$ ) (Table 1).

Ninety per cent of respondents ( $n = 44$ ) perceived that the patient *did* gain weight while in secure care; and 10% ( $n = 5$ ) did not know. Furthermore, 92% ( $n = 45$ ) either agreed/strongly agreed with the statement '*Patient weight gain is a significant issue in secure care*'; and 8% ( $n = 4$ ) neither agreed/disagreed.

The perceived weight gain in the patient's first year of admittance varied greatly: from some staff saying that they did not know if the patient gained weight to others estimating a gain of five stones (31.75 kg). The most common estimate was one stone (6.35 kg).

**TABLE 1** Survey results – age, gender and profession of participants and possible causes for patient weight gain

Gender	Number and percentage of respondents	
Male	$n = 18$	37%
Female	$n = 29$	59%
Prefer not to say	$n = 2$	4%
Prefer to self-describe	0	0
Age range		
18–25 years	$n = 5$	10%
26–35 years	$n = 12$	24.5%
36–45 years	$n = 15$	31%
46–55 years	$n = 12$	24.5%
56–65 years	$n = 5$	10%
65 years+	0	0
Professional role		
Allied health professional (HCPC registered)	$n = 14$	29%
Associate practitioner	$n = 6$	12%
Clinical lead (nursing)	$n = 6$	12%
Doctor	$n = 1$	2%
Healthcare assistant	$n = 8$	16%
Management	$n = 5$	10%
Sessional staff (e.g., sport/woodwork/gardening/recovery college)	$n = 4$	8%
Other	$n = 5$ nurse consultant/psychologist/studentx2/specialist nurse	10%
Possible cause for weight gain		
Medication	$n = 45$	92%
Lack of exercise	$n = 47$	96%
Snacks, for example, from hospital shop/recovery college/visitors	$n = 47$	96%
Food-based activities, for example, with occupational therapy/recovery college/ward	$n = 35$	71%
'Section 17 leaves'	$n = 22$	45%
Secure outreach transition team	$n = 13$	27%
Poor sleep hygiene	$n = 33$	67%
Emotion	$n = 37$	76%
Trauma	$n = 30$	61%
Genetics	$n = 20$	41%
None of the above	0	0
Other	$n = 20$	41%

Abbreviation: HCPC, The Health and Care Professions Council.

Staff were asked why they thought the patient might gain weight, by selecting from the following options: medication; lack of exercise; snacks from shops/visitors; food-based activities (e.g., baking with ward staff/cooking with occupational therapists); section 17 leaves (individuals detained under the Mental Health Act can leave the hospital/ward if granted by authorised doctor/clinician; this is called section 17 leave<sup>21</sup>); poor sleep; emotion; trauma; genetics and 'other' (with free text for 'other'). Participants were encouraged to select as many options as they liked. Lack of exercise and snacks from the shop/visitors were most selected, followed by medication (Table 1).

'Other' included, for example, 'Boredom' (anon); 'Take-aways' (anon); 'Tension between duty of care v patients' capacity' (anon); 'socioeconomic background' (anon).

Staff were subsequently asked to prioritise which three of the above options did they think were the main issues. Staff perceived the main issues to be:

- Snacking:
  - 'The main issue...is the snacking and the weekly purchases of large quantities of sweets, chocolate and pop' (anon)
- Food-based activities:
  - 'Activities don't always have to be about food' (anon)
- Lack of exercise:
  - 'Patients do minimal exercise, and this is sometimes further reduced by staff shortages which leads to sessions being cancelled' (anon)
- Medication:
  - 'Many service users are prescribed antipsychotics and antidepressants. A common side-effect of these drugs is weight gain' (anon)
- Lack of education of staff and patients:
  - 'If staff...have a basic knowledge and skills around this (weight management) then they cannot help patients address the problems adequately' (anon)
- A combination of issues:
  - '...no single main issue, it's a combination of them all that creates a perfect storm' (anon)
- Boredom:
  - 'I think they get very bored' (anon)
- Emotion and trauma:
  - 'If a service user feels hopeless...they may use...the coping mechanism of eating' (anon)
- Lack of patient motivation:
  - '...due to their emotions and mental health as well as motivation' (anon)

Most participants, 90% (n = 44), agreed/strongly agreed with the statement 'Patients who do gain weight in secure care are likely to develop long term health problems'.

In addition, 98% (n = 48) agreed/strongly agreed with the statement 'There are health consequences to being overweight/having obesity'.

All staff were able to name some physical health conditions linked to obesity, including diabetes, heart disease, stroke, cancer, poor mobility, musculoskeletal problems, hypertension, high cholesterol, fatty liver, osteoarthritis, breathing difficulties, sleep apnoea, COVID-19, fatigue, nutritional deficiencies and skin problems. Several staff stated that there were consequences to patients' mental health resulting from obesity such as depression, anxiety, poor mental health, poor self-esteem, poor self-image and poor self-worth.

Staff suggestions regarding *how* to manage patient weight gain included:

- Educating staff and patients:
  - 'Education of staff and patients' (anon)
  - 'Giving staff training around food so that patients are supported in the right way' (anon)
- Increased exercise and types of activities:
  - 'Opportunities to exercise regularly. Making this more varied to include cycling, swimming, team sports and other physical exercises that we have patient interest in' (anon)
- Healthier/less availability of snacks:
  - 'Fairly priced healthier snacks in hospital shop' (anon)
  - 'Reduce the snacks available...somehow limit money spent on poor food items' (anon)
- Less food-based activities:
  - 'Sessions should revolve less around food' (anon)
  - 'I think we could change how many activities we facilitate revolving around food. For instance, not winning food treats for bingo – use alternatives such as toiletries' (anon)
- Better hospital food:
  - 'Hospital food could be better' (anon)
  - 'Balanced hospital menus that patients find hard to resist (visually pleasing) and therefore do not feel the need to supplement their diet with snacks or take-way' (anon)
- Staff role-modelling:
  - 'Staff leading by example' (anon)
  - 'Promote healthy eating and exercise for staff too!' (anon)
- 'Best interests'/ability to say 'no' to patients:
  - 'The ability to say no to patients (restrictive practice) – this would not happen in a General Hospital' (anon)
  - 'Staff support around what can be reasonably done to restrict where necessary' (anon)
- Policies/whole-system strategy:
  - 'Need an overarching strategy everyone agrees to...' (anon)
- Non-food emphasis for section 17 leaves:
  - 'New focus for leaves' (anon)
  - 'Leave not being centred around the garage' (anon)
- Better motivators for patients: 'Find other motivators' (anon)'A different approach as to what we offer and also how we engage with patients' (anon)

## Phase two: semi-structured interviews

Twenty staff opted to participate in the semi-structured interviews: 60% ( $n = 12$ ) from forensic secure care LD wards, 10% ( $n = 2$ ) from forensic secure care MH wards and 30% ( $n = 6$ ) who covered both.

A sample of 12 staff were purposively selected and were invited to interview. The purposive sampling ensured that there was a range of disciplines, grades and worksites. Due to dropouts, a total of nine staff were interviewed, including AHPs, psychologist, psychiatrist, nurse, assistant practitioner, ward manger and sessional staff (e.g., woodwork/sport).

The following themes on why weight gain may occur in secure care emerged from the interviews.

### Theme 1: the 'forensic patient'

Staff perceived that some traits which might contribute to a susceptibility to weight gain were specific to the forensic patient group, suggesting that people who are detained in secure care often come from deprived backgrounds and therefore may have previously experienced food insecurity and had poor diets prior to admission. Often their lives have been chaotic and abusive, with poor role models and experiences, which would not be conducive to learning how to eat well.

*'I'm sure that some of them (patients) have had lack of availability of food. I mean, I've seen people coming in who have literally stuffed their faces when they come into hospital. I remember one patient in particular coming in, and it was like he hadn't eaten for a month, he was just ravenous... if I had to guess what was a predominant theme, it would have been neglect and lack of availability of food, even relatively basic food, never mind treats' (P8).*

*'... they've perhaps had quite deprived... experiences or neglectful experiences' (P7).*

These individuals were seen to be prone to impulsivity and making poor choices. These factors were cited as possibly contributing to their detainment in secure care, and it was assumed that this would also be reflected in food-related behaviours.

*'They are in our service because they make bad choices, so we try to stop them. ... We try to manage their bad choices in respect of their offending behaviour' (P9).*

*'We know a lot of our patients are prone to being quite impulsive' (P7).*

Patients may also have been mentally unwell and therefore underweight on admission, thus creating an artificial weight increase at the start of their pathway. In addition, mentally unwell people may be unmotivated to change weight-related behaviours.

Some patients may have experienced trauma and may use food as an emotional regulator, particularly around comfort/anger. Emotional eating was often cited as a possible reason for 'binge-eating' snacks. It was questioned whether some patients, particularly those with a learning disability, were able to label their emotion or understand how they feel.

*'...if you're not able to label your emotions or you're not able to recognise your emotions, and you're applying a coping strategy...that actually ends up in you not feeling very good about yourself, then that's a vicious cycle isn't it?' (P4).*

The change in lifestyle on admission, particularly a reduction in physical activity, was seen as a significant reason for weight gain. For example, some patients may be legally restricted to the ward due to their risk and were likely to have been more physically active prior to admission.

*'If that individual...was very active beforehand and his mental health has massively declined and is now very inactive and spends most of his days in sedentary pursuits, then that'll have a massive impact on what he's burning through, if he's still consuming the same amount of calories that he was before' (P5).*

*'I know of instances where people aren't allowed off the ward at all. So that would mean that they won't be able to go to the gym, to the sports hall, anywhere. And I think just being in that day-room... it is a struggle' (P2).*

Staff frequently referred to the patients lacking autonomy, other than money and food, thus making food more appealing.

*'I think, there's something about... what patients can influence and what choices they can make and what control they have so, I think perhaps in an environment where they there's limited kind of opportunities to exert choice and control in lots of aspects of their life, then that's something that they can' (P7).*

*'...it's the items that are in your control.... "If it's my money I can spend it on what I want"; "If it's my food I can eat what I want"' (P5).*



Poor sleep patterns and eating snacks late into the night were cited as being unhelpful practices for weight management.

Staff reported that patients might be unaware of their weight gain. This may be due to their mental health or learning disability, but also because many wear stretchy clothing, do not have access to mirrors or buy new clothes.

*'... how do you know if you've gained weight if you are wearing stretchy clothing? If you can't see yourself in a mirror? Or if you're not going out to the shops to buy clothes and having the experience of them not fitting?' (P4).*

## Theme 2: staff confidence and self-efficacy around weight

Staff reported a culture of fear of 'challenging' patients, for example, saying 'no' to food requests or offering advice around food choice. This was partly due to fear of threats and/or violence from patients, but mainly due to the threat of being reported to the CQC. Staff were unhappy about the helplessness they felt when the patients were making poor food choices and gained weight.

*'...it's restrictive practice, isn't it? And CQC and all of that...there's all those fears and worries... but I think it's led to patients becoming seriously overweight...for me I struggle...because I'm a nurse and I feel I've got a duty of care to patients to... not allow them to become overweight and then have other health conditions associated with that weight gain' (P3).*

It was thought that some staff might use food to reduce incidents; for example, it is easier to give a patient additional bread than to cause an incident.

Staffing levels were mentioned as a reason for patients being unable to have daily walks around the grounds. Some patients require certain escort levels when off the ward, and this cannot always be provided. In addition, the lack of activities, especially at weekends, was seen to contribute to boredom eating.

*'A lot of patients would love to just go out for a walk every day, even if it was just around the grounds, but some of the time that can't be facilitated for them, which is really quite sad, 'cause it is a fundamental need, I would've said' (P2).*

Participants noted that staff may struggle with their own weight and/or may have a poor relationship with food. It was suggested that staffs' own food beliefs were

transferred onto the patients. Furthermore, it was observed that staff can give conflicting/poor dietary advice to patients.

*'I wonder whether what we're seeing is we're just seeing staff playing out their relationships with food in their care... not necessarily conscious' (P4).*

*'I think the patient...probably has had a lot of conflicting advice on what is an appropriate diet. I think everybody has an opinion on what's healthy and therefore impose their opinions and values on patients, which isn't always helpful...' (P6).*

It was felt that assessing capacity around food is difficult. Patients often express themselves by violence/aggression, making it difficult for staff to enforce a 'best interests care plan' should capacity around food choice be deemed lacking.

## Theme 3: difficulties from living within a secure care environment

The secure care environment can result in restricted movement for many patients; this can be worse at the start of their pathway.

*'...coming into these sort of environments, you lose your freedom...you automatically don't have the ability to just get up and wander here, there and everywhere as you typically would living out in the community' (P5).*

Onsite shops, canteen and local shops were cited as not providing any/limited healthy snacks. Patients often buy large quantities when visiting these premises, and there are limited options other than food. Patients detained under the mental health act are in receipt of benefits, and this can result in them having large sums of money with very little to spend it on.

*'...why are we not making it easier for people to make healthier choices?' (P4).*

*'...I just think £20 a week is a lot for anyone to be spending just on snacks' (P2).*

The Mental Health Act stipulates section 17 leaves are to be part of the therapeutic treatment pathway and must have a purpose.<sup>21</sup> Often, they are used to visit a food outlet, for example, the canteen or the hospital shop. This practice has occurred for many years.

Family and carers can bring in large quantities of food during visits. Due to restrictions of what can be



brought into the secure care environment they may be unsure of what else they can bring their relatives. And, food is often linked to care, love and nurturing.

*'...we quite often get members of the family bringing up huge stacks of food for people because (of)...the association between food and love and all of that sort of thing and the limited other things that people feel that they can do in order to help their loved one when they're in hospital' (P8).*

Many of the anti-psychotic medications can lead to increased weight gain and increased appetite. Although staff acknowledged this, these were not considered to be the main factor contributing to patient weight gain in the interviews.

Staff reflected that the hospital menu is a cause for distress and unrest among patients. Some staff believe that the portions are too small, resulting in the patient being given additional bread at mealtimes and/or additional snacks. Some patients are in secure care for several years; consequently staff observed the 4-week menu cycle as being monotonous.

*'...I do feel for them you know, you've been in hospital for X amount of years, you're on a four weekly menu...they must get sick of it' (P4).*

It was perceived that staff provide additional food/meals to compensate for this monotony. Other issues around the menus include the patients not getting what they order on occasion, which can result in the patient becoming upset and binge eating on snacks instead.

Many patients would like to cook for themselves, but the facilities for this are poor. It was also noted when patients do cook for themselves, it can be difficult to manage portion sizes for one.

The treatment focus for patients in secure care is on risk management: trying to ensure that they do not offend again. Therefore, physical health, particularly weight, is often a secondary concern.

*'...their diet and what they eat is somewhat incidental to the primary role which is risk management of their offense... their past history of offending...' (P9).*

*'...if that meant that they ate a bit more...you know he eats a bit more and he's a bit overweight but he's not going to go in and do the things he did before – yeah on balance you know how I'm perceiving things that's a win' (P9).*

*'...and being holistic, I think (staff) who work in mental health...we sometimes forget about that physical health...' (P6).*

#### **Theme 4: how the patient may feel about weight gain**

Staff reflected that weight gain might make the patient unhappy, 'lethargic' (P5 and P6) and 'sluggish' (P2) and may affect their mental health.

*'I don't think anyone's happy with their weight gain...' (P7).*

*'I think they don't want to gain weight, but they can't help it...' (P1).*

It was suggested that patients might not understand the consequences of gaining weight, particularly in the learning disability service, and/or that they might not be motivated, might be too unwell or might not know how to reduce their weight.

Many patients have poor self-esteem and body image, and a lot of work is done to improve this. There was acknowledgement that weight gain is likely to make the patient's self-esteem/body image worse.

*'...most of our patients have got real difficulty with their self-esteem and obviously that is linked to your weight and body-image' (P9).*

#### **Theme 5: complexity around 'treats'**

The word 'treat' made all participants think of food, which is usually high in calories, fat and/or sugar. There was a consensus that although non-food treats are possible, they are harder to provide for in secure care.

Treats were seen as 'pleasurable' (P6) and 'something that gives you a boost' (P3) or that 'makes you happy' (P2).

*'(people used food to treat themselves) because it feels good...it's an incredibly reinforcing experience to eat something nice...it's one of life's pleasures, isn't it?' (P8).*

Treats were seen as a reward, something special/extra to make you feel good or to counteract a negative experience. Participants thought that treats were individualised and often learnt from childhood.

*'I think it's (a treat) something pleasant, isn't it? It creates a pleasant feeling. A kind of cared for or... caring for feeling' (P4).*

To be a treat, it had to be a food which was eaten infrequently. If the food was eaten on a regular basis, then it was thought to become a habit or would have less appeal.

*'...something that you may be reward yourself with for doing something well, or you know, for a special occasion or is a bit of a...not a one off as such, but you know rare, not the norm. Not something you would have all day every day' (P6).*

*'I guess that's what I would say is a treat – something a bit out of the ordinary and because of that, you can maybe get away with it being a bit naughty, shall we say?' (P8).*

The consensus was that it is possible for food treats to be part of a healthy diet, but *only* if the overall diet is healthy and balanced. In addition, the frequency and size of the treat is also deemed to be important.

*'...you can incorporate something as a treat but it's about balancing it with other things you do, so that kind of balancing the books isn't it really?' (P4).*

Some staff held a firm belief that patients would not attend activities if food was not provided. Food treats were seen as an easy option used to 'entice' or 'engage' patients to attend activities.

*'I think it's (food at activities/sessions) a sure-fire way of getting people to attend groups' (P2).*

*'So I think sometimes it food can be used as a bit of a carrot to try and entice people to engage in, kind of, therapeutic activities or things like that' (P7).*

However, some staff reflected that there was no difference in patient attendance if food was/was not provided; perhaps providing a treat was more for the clinician's confidence rather than for patient engagement.

*'No! No difference (to a patient attending a session). I think maybe there's a comfort... or a confidence for you as a clinician that if I do this (provide food) then people will definitely do it' (P4).*

Food treats were viewed as cheap, available to all and do not require much staff time or resources. They do not require much thought; most people are able to participate and are interested in eating.

*'Food as a treat is easy, it's accessible, doesn't cost very much, and either monetarily or in staff in-put and time' (P9).*

The participants observed that some people enjoy feeding people, that food is seen as love/care/nurture. It was agreed that, overall, most staff are caring, compassionate and like doing something enjoyable for the patients, such as cooking or providing food treats.

*'...it feels like a nice thing to do for the patients...if you can see that the patients enjoy kind of eating or having kind of treats...' (P7).*

*'...it's (treats/food) tied into feeling loved, it's tied into having a special experience...it's tied into the family and...the staff appearing to care for someone...I think it's got its fingers quite deeply embedded in lots of fairly profound areas and that's why it's so powerful' (P8).*

In contrast, staff thought that sometimes food might be used as a tool or motivator to get patients to behave in a certain way and that food might be used to appease patients and/or to keep the peace.

*'...maybe people use it (treats)...for a bit of an easy life...because it does normally – it wins people over doesn't it?' (P6).*

*'To keep the peace; keep them settled.... I mean, there's not much more you can say... that really is it in a nutshell' (P1).*

*'Now, I'll guarantee that wards will not have much... not many problems on the night that they're gonna have that takeaway because they know if they, if they misbehave or if they have to do something that they shouldn't do, the chances are that they could be stopped from having that take away, so it'll be settled' (P1).*

## **Theme 6: improvements to make managing weight in secure care easier**

Staff proposed that earlier intervention in the patient pathway in secure care could be paramount to minimise patient weight gain. They felt that once a patient has

gained a significant amount of weight, it may seem too big an undertaking to manage.

*'I guess quite a lot of them are quite significantly overweight, it perhaps feels like kind of where do you...? This is too... big a task to try to undertake' (P7).*

There were recommendations that collaboration was needed by *all* staff, making it a whole multidisciplinary team (MDT) issue. Staff felt that delivering a whole system approach, such as an ongoing health promotion campaign throughout the year, suggesting that more dietitians were required to support this. The involvement of staff in health-related activities by role-modelling was seen as an important step to support patients.

Alternative interventions which use a more behavioural approach rather than a medical model were recommended. This would also involve work around emotions and emotional eating.

There were several proposals for the need to make it easier to facilitate healthier choices and more difficult to make less healthy choices in the on-site facilities, for example, hospital shop. The hospital menu was almost unanimously seen as an area which required modification and change.

Section 17 leaves are often used to visit food outlets/destinations, for example, hospital shop/canteen/local shop. It was recommended that alternatives are given so that patients maintained a purpose for their leave but without the leave being food focused.

It was perceived that both staff and patients required training and education on weight management, to ensure that consistent messages are given. Restrictive practice verses duty of care was seen as a blurred area, and clear guidance and training on this is essential.

## DISCUSSION

This study shows that a high proportion of staff in secure inpatient services are concerned about patient weight gain and highlights the helplessness perceived by staff when patients gain weight, referring to fear of repercussions from the CQC.<sup>9</sup> Although the CQC's recommendations on providing the least restrictive care are important, it is a complex area for staff to navigate with certainty. This may have a significant impact on patient weight gain and consequential health impacts.

This study has shown that staff perceive there to be several environmental issues which might contribute to patient weight gain, for example, lack of available healthy options in hospital shops, section 17 leaves to shops/food outlets and food-based activities. Furthermore, the results indicate that there may be traits specifically related to patients detained in secure care that increase their vulnerability to increased food intake

and weight gain, including previous trauma, deprivation, impulsivity or being prone to making poor choices.

Patients in secure care can be harder to engage,<sup>22</sup> often staying in their rooms for long periods of time. This study has shown that food is often used as an enticement to participate in activities, therapeutic or otherwise. However, individual patients can be subjected to this 'enticement' using food on numerous occasions in any given day/week.

Although obesogenic antipsychotic medications, such as clozapine and olanzapine, are often used as a first choice of treatment in this setting<sup>11</sup> and were seen as a legitimate cause for weight gain, many staff did not view them as being the only reason. The primary reason cited was the large volume of snacks, often purchased on-site, often as part of section 17 leave from the ward, granted under the Mental Health Act.

The recent review by the Department of Health and Social Care on hospital food<sup>23</sup> highlighted that long-term inpatients in mental health hospitals may become fatigued by a rotational menu. This research aligns with the existing evidence, reporting that not only are patients bored of the food choice, but some of their behaviours that challenge may also be as a direct result of the monotony. In addition, staff are seen to provide alternative meals, often in large volumes and energy-dense, to break the repetitiveness.

Although there are limited studies on treat-giving in this setting, there is some literature regarding treat-giving behaviours between parents/grandparents and children. Pescud and Pettigrew (2014) found that parents treated their children daily to 'control their children's behaviour, to demonstrate love and affection, and to address deprivation beliefs'.<sup>24</sup> Similarly, findings in this research suggest that treats may be used in this way for patients in secure care. The results of this study align to those seen of treat-giving by adults to children.<sup>12</sup> There appear to be similarities between treat-giving to children by parents and grandparents<sup>12,24-26</sup> and the 'treat-culture' in these environments. This type of paternal caring for adult individuals may make the patients feel like they are having things 'done' to them, rather 'with' them.<sup>27</sup>

Treat-giving in secure care is often seen to provide pleasure to patients, often to reward and entice them to undertake therapeutic activities, in a similar way to that seen by Pankhurst et al.<sup>25</sup> suggesting that grandparents 'spoil their grandchildren with excessive amounts of discretionary foods'.

Existing evidence indicates that patients detained in secure care settings are more likely to become overweight or obese than the general population.<sup>5,8</sup> Staff attributed patient weight gain to multiple factors, which closely aligns to previous research findings.<sup>28</sup> However, the existing evidence base is derived from patient-reported data. This is, as far as we are aware, the first study exploring inpatient staff's perceptions on patient weight gain in a forensic secure care setting. As staff are integral

to the food culture in this environment, it is important to understand the staff perceptions on patient weight gain to address these fundamental issues.

## LIMITATIONS OF THE STUDY

This study was conducted in one NHS Trust and, as such, the findings may not be generalizable to all NHS forensic secure care settings and patients. Due to the impact of COVID-19, phase one of the study was conducted as an online survey, avoiding face-to-face contact. This may have excluded some staff groups who do not access their emails regularly. In addition, the gatekeeper for survey dissemination was via line managers; as such, some staff may have been missed, and it was not clear how many staff received the survey.

The survey asked for participants' profession. Due to the small number of staff in some professional areas, it may have been possible for the researcher to identify individuals. Some staff verbally reported they did not want to participate for this reason.

Participants were recruited to semi-structured interviews (phase two) through expressions of interest following the survey. Some clinical staff may have required clinical cover to participate in the interview. Consequently, some staff may have needed to disclose their participation to other staff/managers. These factors may have resulted in recruitment bias.

The researcher conducting the interviews was a dietitian who works alongside the participants, which may have influenced participants' responses.<sup>29</sup>

## CONCLUSIONS/RECOMMENDATIONS

This is one of the first studies to explore staff views and staff perceptions on patient weight gain, understanding 'treat-culture' and the use of food treats given to patients in secure care.

The findings indicate that there are multiple factors which may influence patient weight gain, such as the patient's history, staff behaviours and the secure care environment. Staff are concerned about the impact weight gain has on patients' physical and mental health and yet can feel helpless about patient weight gain. The study suggests that treats are an enjoyable part of life which may be incorporated into a healthy diet. However, the frequency and volume of treats in secure care may tip that balance. The treats in the forensic secure care environment were perceived to have become habitual, making the patient's diet high in fat, sugar and calories.

There is a requirement for clear guidance on what restrictions are reasonable and proportionate in supporting patients with their weight. Secure care services need

to provide holistic care, recognising that the patient's complex history may contribute to their relationship with food and healthful behaviours. It is important that there are discussions with patients regarding changes to their food/activity. Communication between disciplines and shifts could help minimise the frequency of treats. Thought must be given to menu variety, the wider trust food environment and food activities provided. Alternatives for section 17 leave which does not involve a food outlet are required. There is a need for a whole system approach to weight management/health promotion<sup>11</sup> which focuses on the patient pathway and staff values, in which staff's own health beliefs need to be recognised. Staff as role models, participating in health promotion and healthful activities, is an important consideration for patient participation in these initiatives.<sup>4</sup>

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

## AUTHOR CONTRIBUTIONS

Anita Attala conceived the idea for this research, applied for ethical approval, collected and analysed the data. Anita Attala, Jo Smith and Emma Giles designed the study. Amelia Lake advised on the study design and write-up. All authors contributed to the writing of this paper.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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## PEER REVIEW

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## Appendix A: the survey

### SECTION 1: about you

1. **Do you identify as?** (*drop-down box*)

- Male
- Female
- Prefer not to say
- Prefer to self-describe

2. **Which age range are you?** (*drop-down box*)

- 18–25 years
- 26–35 years
- 36–45 years
- 46–55 years
- 56–65 years
- 65 years and above

3. **What best describes your role?** (*drop-down box*)

- Allied health professional (HCPC registered)
- Associate practitioner
- Clinical lead (nursing)
- Doctor
- Health care assistant
- Management
- Sessional staff, for example, sport/woodwork/gardens/recovery college and so on
- Other

If 'other' please state how you would describe your role \_\_\_\_\_

4. **How long have you worked in secure care services?** (*drop-down box*)

- 0–1 year
- 2–5 years
- 6–10 years
- 11–15 years
- 16 years or more

5. **Which site do you work onto?** (*drop-down box*)

- Northgate Hospital
- Bamburgh Clinic
- Both Northgate Hospital and Bamburgh Clinic

### SECTION 2: your views and opinions on patient weight gain in secure care services

6. **In your opinion, does a patient generally gain weight while in secure care services?** (*drop-down box*)

- Yes
- No (please go to Q8)
- Don't know (please go to Q8)

7. **If 'yes' to question 6, in your opinion, how much weight does an average patient gain in the first year as an inpatient in CNTW's forensic services?**

\_\_\_\_\_ -  
\_\_\_\_\_

8. **Please indicate your agreement to the following statement 'Patient weight gain is a significant issue in secure care'** (*drop-down box*)

- Strongly agree
- Agree
- Neither agree/disagree
- Disagree
- Strongly disagree

9. **Please can you explain your answer to question 8?**

\_\_\_\_\_ -  
\_\_\_\_\_

10. **In service users who do gain weight while in CNTW's forensic inpatient services what, in your view, might have caused this? Please tick all that apply**

- Medication
- Lack of exercise
- Snacks, for example, from hospital shop/recovery college/visitors
- Food-based activities, for example, with occupational therapy/recovery college/ward
- 'Leaves'
- Visits with Secure Outreach Transition Team (SOTT)
- Poor sleep hygiene
- Emotion
- Trauma
- Genetics
- None of the above
- Other

If 'other' please state \_\_\_\_\_

11. **Out of the issues you identified in the previous question (Q.10) which, in your opinion, is/are the main issue(s) and why?**

### SECTION 3: your views and opinions on obesity and health

12. **Please indicate your agreement with the following statement 'Patients who do gain weight while in secure care are likely to develop long-term health problems'.** (*drop-down box*)

- Strongly agree
- Agree
- Neither agree/disagree
- Disagree
- Strongly disagree

13. **Please indicate your agreement with the following statement 'There are health consequences to being overweight/having obesity'.** (*drop-down box*)

- Strongly agree
- Agree
- Neither agree/disagree

- Disagree
- Strongly disagree

14. If you have selected 'strongly agree' or 'agree' to Q.13, in your view, what are the health consequences of being overweight/having obesity? (please list as many as you like).

**SECTION 4: your views and opinions on what could be done to minimise patient weight gain**

- 15. For patients who do gain weight while in CNTW's forensic inpatients what, in your opinion, could be done to reduce the amount of weight gained?
- 16. Please comment if you have anything that you would like to add/discuss further

**SECTION 5: taking part in a semi-structured interview**

- 17. Following on from this survey, interviews are going to be conducted to explore views and opinions on patient weight gain further. Would you like to receive further information on the interview process, to inform you whether or not you would like to take part in an interview?

- Yes
- No

If 'yes', please leave your **name and email** so that you can be sent some further information to help you decide if you want to take part in the interview at a later date.

**Name:** \_\_\_\_\_

**Email:** \_\_\_\_\_

If you would rather not leave your contact details here but would like to participate or find out more about the interviews please do not hesitate to contact me Anita Attala, Advanced Dietitian, directly on: email: [anita.attala@cntw.nhs.uk](mailto:anita.attala@cntw.nhs.uk) or telephone: 07812 483999

**Thank you!**

Thank you for taking the time to complete this survey. I appreciate the time that you have taken.

Should you have any comments or questions, please feel free to contact any of the research team using the details on the participant information sheet.

## Appendix B: the semi-structured interviews

**Section 1:** for the purposes of the recording, please can you say your **name, your position and where you work.**

### Section 2: thinking about patient weight gain

Case study: Patient X, 32-year-old male who gains 2 stone (15 kg) in his first 6 months as an inpatient.

1. What in your opinion are the reasons for the weight gain seen in patient X?
  - Anything else...
2. How do you think patient X feels about his weight gain?
  - Do you think staff may have contributed to this feeling in anyway?
3. What safety-nets or systems could be put in place to avoid/minimise the weight gain seen in this patient?

### Section 3: now thinking about 'treats'

4. How would you define a 'treat' (prompt: both food and non-food)?
5. In your opinion, can food treats be used as part of a healthy lifestyle? Please explain your answer further...
6. People often use food as a way to treat themselves, why do think that is?
7. In your opinion, how do staff use food in relation to patient care? (prompts: to treat/coercion/easier shift)
8. Why do you think food treats/activities are used?
9. How could patients have treats without food? Can you give examples?
10. Do you think that there's a link between treat giving and patient weight gain?

### Section 4: ideas/comments

11. Do you have any ideas/comments on treats/treat giving/patient weight gain which we've not covered?

**Thank you** Thank you for taking the time to complete this interview. I really appreciate the time that you have taken. If you have any comments or questions, please feel free to contact me using the details on the participant information sheet.

# Effectiveness of dietary interventions delivered by digital health to adults with chronic conditions: Systematic review and meta-analysis

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## Abstract

**Background:** Digital health interventions may facilitate management of chronic conditions; however, no reviews have systematically assessed the effectiveness of dietary interventions delivered by digital health platforms for improving dietary intake and clinical outcomes for adults with diet-related chronic conditions.

**Methods:** Databases CINAHL, CENTRAL, Embase and MEDLINE were searched from inception to April 2021 to identify controlled trials for dietary education delivered by digital health (mobile or electronic health) to adults with diet-related chronic conditions. Random effects analysis was performed for diet quality, food groups, nutrients and clinical outcomes. Screening, data extraction and quality checking were completed in duplicate.

**Results:** Thirty-nine studies were included involving 7333 participants. Significant changes were found for Mediterranean diet adherence score (standardised mean difference [SMD] = 0.79; 95% confidence interval [CI] = 0.18 to 1.40), overall fruit and vegetable intake (mean difference [MD]: 0.63 serves/day; 95% CI = 0.27–0.98), fruit intake alone (MD = 0.58 serves/day; 95% CI = 0.39 to 0.77) and sodium intake (SMD = -0.22; 95% CI = -0.44 to -0.01). Improvements were also found for waist circumference [MD = -2.24 centimetres; 95% CI = -4.14 to -0.33], body weight (MD = -1.94 kg; 95% CI = -2.63 to -1.24) and haemoglobin A1c (MD = -0.17%; 95% CI = -0.29 to -0.04). Validity of digital assessment tools to measure dietary intake were not reported. The quality of evidence was considered to have low to moderate certainty.

**Conclusions:** Modest improvements in diet and clinical outcomes may result from intervention via digital health for those with diet-related chronic conditions. However, additional robust trials with better reporting of digital dietary assessment tools are needed to support implementation within clinical practice.

## KEYWORDS

chronic disease, diet, dietary intake, electronic, internet, mobile

## Key points

- Digital dietary interventions may result in modest improvements in diet and clinical outcomes; however, quality of evidence was considered to have low to moderate certainty.

- Validity of digital assessments tools to measure intake were not reported in the selected studies.
- Additional robust trials are needed with better reporting of digital dietary assessment tools to support translation into practice.

## INTRODUCTION

Diet-related chronic conditions are increasingly prevalent, causing significant strain on healthcare systems and individuals worldwide, including cardiovascular disease, diabetes, obesity and chronic kidney disease. In 2017, dietary risk factors were associated with approximately 11 million deaths and 255 million disability adjusted life years globally.<sup>1</sup> Dietary interventions can positively influence outcomes in chronic conditions<sup>2</sup>; however, providing this care remains a challenge. Despite health services reaching capacity with increased patient numbers, clinical workforce burnout and shortages, all intensified by the COVID-19 health pandemic,<sup>3</sup> attending appointments for face-to-face care remains the predominant service delivery for chronic disease management.<sup>4-6</sup> Therefore, better strategies are urgently needed to manage chronic conditions and ensure that no health disparities exist.

There is growing evidence that digital interventions offer feasible healthcare solutions. Electronic health (eHealth) relates to the electronic delivery of health information, resources and services, whereas mobile health (mHealth) uses mobile technologies to deliver health information and practices using wearable devices or mobile applications (apps).<sup>7</sup> The use of these technologies in the community has extensively increased over the last few years. For example, smartphone subscriptions increased globally from approximately 2.6 billion in 2016 to 6.3 billion in 2021,<sup>8</sup> with many users engaging with mobile health applications.<sup>3</sup> The ownership and high use of digital health suggest an affordable and scalable public health strategy.

Furthermore, evidence is emerging around the effectiveness of digital health for dietary management. It allows participants to electronically record their dietary intake to either share with a health professional or for self-monitoring.<sup>9</sup> Digital health can increase engagement by the patient, which has been linked to shared responsibility and decision making, and trust in care between the health professional and patient.<sup>10</sup> In addition, patients have increased flexibility to access these services at a suitable time and location, helping to address perceived patient burdens, healthcare inequity and healthcare resource efficiencies. However, despite the increased value proposition,<sup>11</sup> the efficacy of digital health interventions remains unclear for certain population groups and dietary interventions.

There is an opportunity to build further knowledge on the delivery of dietary education and monitoring via

digital health. Although there are a number of systematic evaluations on the effectiveness of these types of interventions<sup>12-19</sup>; few have been conducted to specifically examine diet-related chronic conditions.<sup>13,16-18</sup> Most of these reviews that have examined diet-related chronic conditions, have involved or focused on telehealth and telephone more broadly with limited evaluation on mHealth and eHealth technologies, which is an important gap in the literature that needs addressing. In addition, there is a lack of research evaluating digital dietary assessment methods used in digital health interventions, with no review to our knowledge summarising this detail. Therefore, the aim of this systematic review is to determine the effectiveness of dietary interventions delivered by digital health for improving dietary intake and clinical outcomes for adults with diet-related chronic conditions. The findings from this systematic review and meta-analysis will help to inform evidence-based dietary care strategies for clinical practice, and to identify further research prospects for improving the design of digital health interventions.

## METHODS

This systematic literature review was reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The Cochrane handbook for systematic reviews guided the risk of bias assessment, analysis of data and interpretation of results.<sup>20</sup> The research protocol was registered in PROSPERO (CRD42021269363).

### Search strategy

A search was conducted using electronic databases CINAHL (via Ebscohost), Cochrane CENTRAL, Embase and MEDLINE (via Ebscohost) from inception to 30 April 2021. A combination of key search terms and medical subject headings were used in the search strategy in consultation with a University librarian trained in systematic literature reviews (see Supporting information, Table S1). No restrictions for language, year of publication or any other filters were used. If any non-English articles were identified, Google translator was used to fully appraise the inclusion criteria.<sup>21</sup> Additional articles of studies that met our inclusion criteria and were published within the search date were included via snowballing methods.

## Study selection

Results were imported into endnote and deduplicated before independent screening by three of the investigators (AB, CW and CS). Eligible study designs were randomised and non-randomised controlled trials. Single arm studies, observational, cross-sectional, qualitative designs and grey literature were excluded. Adults aged  $\geq 18$  years with an established diet-related chronic disease met the inclusion criteria. Diet-related chronic conditions included heart disease, stroke, hypertension, obesity (defined as a body mass index [BMI]  $> 30$  kilograms per metre squared [ $\text{kg}/\text{m}^2$ ]), diabetes mellitus (DM), chronic kidney disease (CKD) or liver disease. Studies which reported a mixed study sample (e.g., overweight and obesity) were reviewed and only included if the results of that portion of the sample were reported separately or the overall mean was  $>30 \text{ kg}/\text{m}^2$ . Studies with at least one dietary education component delivered by a digital health modality to patients in any setting and at any dose met the inclusion for this review. Digital health included mHealth or eHealth technologies, such as mobile apps and messaging systems, internet-based and electronic software systems. If studies only included telephone and video conferencing, without any other mHealth or eHealth components, they were excluded because they have already been reported in previous reviews.<sup>13</sup> The digital health intervention must have either been developed or delivered by health professionals or had its content developed in line with best practice guidelines. The comparison groups were those that received usual care in which provision of non-digital educational resources or standard nutrition counselling. Any disagreements were discussed between investigators or by a fourth investigator (JK). If studies were unclear in any detail related to appraising the inclusion criteria, contact was attempted with the corresponding authors to clarify any required detail.

## Primary and secondary outcomes

The primary outcome of the review was measures of dietary intake that included food or diet pattern scores or indices; food group servings; nutrients or energy intake; diet adherence or self-monitoring scores; and biomarkers of nutritional intake. Secondary outcomes included quality of life (QoL); systolic and diastolic blood pressure (SBP and DBP); measures of blood glucose control including haemoglobin A1c (HbA1c), fasting blood glucose (FBG); blood lipids including total cholesterol (TC), high-density lipoproteins cholesterol (HDL-C), low-density lipoproteins cholesterol (LDL-C), very low-density lipoproteins cholesterol (VLDL-C), triglycerides (TG); anthropometry or body composition including BMI, weight, waist circumference; self-efficacy;

hospitalisation and mortality; and methods of assessing dietary intake.

## Data extraction and management

Relevant data were extracted using a predefined data extraction table by one investigator (AB) and confirmed for accuracy by a second investigator (CW). Data extracted included: citation, author, year, country of origin, number of participants, intervention details, eligibility criteria, length of follow-up, control group details, intervention intensity, mean and variance related to the primary and secondary outcomes, and methods to assess dietary intake. In addition, if available, the validity of digital dietary assessment tools (compared to conventional tools), use of health professional checking for accuracy of digital dietary assessment tools and patient completion/adherence to digital assessment tool was also extracted.

## Assessment of study quality

The risk of bias was completed for all included studies using the Cochrane risk of bias 2.0 tool<sup>20</sup> by two independent investigators (AB and CW). Elements that were considered included randomisation techniques; allocation concealment; blinding of participants, providers and assessors; incomplete outcome data and selective reporting. Conflicts between investigators were managed by a third independent investigator (JK) until consensus was reached. The quality of the evidence was graded using the Grading of Recommendations Assessment, Development and Evaluation methodology (GRADE).<sup>22</sup>

## Statistical analysis

The overall treatment effect for primary and secondary outcomes was calculated according to the differences between the intervention and comparison groups' changes from baseline to the end of the trial for each measured outcome. If changes from baseline values were not provided, the end of follow-up values were used. The variance was reported as the 95% confidence interval (CI), using the standard deviation, standard error or the 95% CI from each of the original studies. Studies that reported sufficiently homogeneous information were imported into the Review Manager, version 5.4 (<https://training.cochrane.org/online-learning/core-softw-are/revman>) for meta-analysis using the DerSimonian-Laird random-effects model.<sup>20</sup>

If an outcome was reported or able to be converted to standardised units then the effect size values were recorded as mean difference (MD) and if there was a variation in units reported the standard mean difference



(SMD) was used. If there were multiple measures within an individual study, the most comparable measure to the other studies within a meta-analysis was used. WebPlot-Digitizer<sup>23</sup> was used to determine the confidence intervals of outcomes that were presented graphically within the paper and not reported elsewhere. If both an unadjusted and adjusted difference were reported in the study, the latter was used. To interpret the SMD values, reference was made to the Cochrane Handbook for re-expressing SMDs using a familiar instrument.<sup>24</sup> To assess inconsistencies between studies,  $I^2$  statistic and variability of effect was used, demonstrated as a percentage. Heterogeneity was considered moderate if 25%–75% and high if > 75%. Sensitivity analysis was considered when heterogeneity was present across the results of included studies.

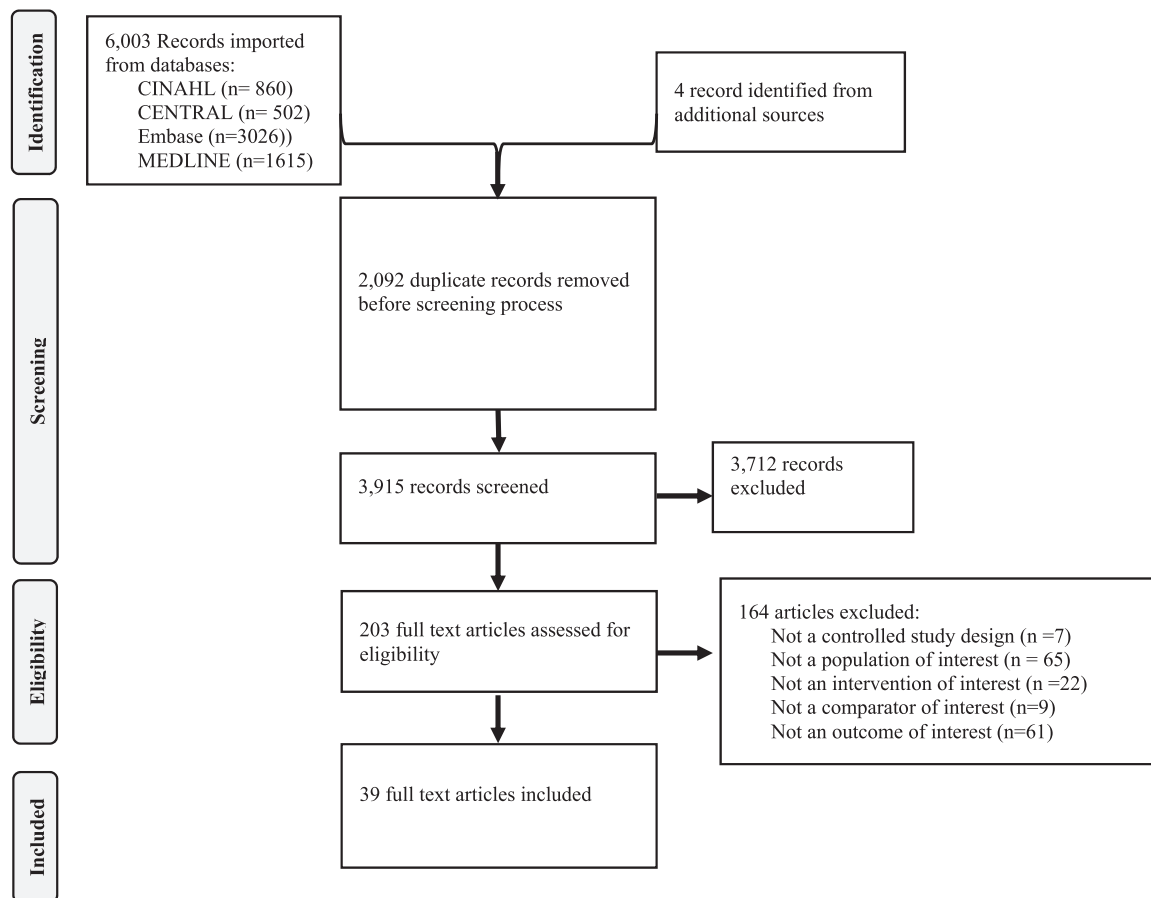
Where sufficient data was reported across studies, subgroup analyses were conducted for diet quality indices (Mediterranean diet or other), type of condition, the use of multiple digital health strategies compared to single digital health strategies, the duration of the intervention and studies that targeted specific nutrients compared to dietary patterns. Although originally planned (Prospero CRD42021269363), as a result of

insufficient detail across the studies, we did not conduct subgroup analysis for age, dietary education provided in the comparison group and dietitians delivering the whole intervention compared to a small component.

## RESULTS

### Characteristics of included studies

The PRISMA flow diagram outlines the steps for selecting the articles included in the present study (Figure 1). The search process identified 6007 records and following removal of duplicates and irrelevant studies, 203 records remained for full text screening. In total, 39 studies with 7333 participants met the inclusion of this systematic review. The characteristics and main findings of the studies are provided in Table 1. Studies were conducted within hospitals ( $n=20$  studies),<sup>25–44</sup> community health care ( $n=16$  studies)<sup>45–60</sup> or a combination of these settings ( $n=3$ ).<sup>61–63</sup> The majority of studies were randomised control trials ( $n=37$  studies) with either two ( $n=31$  studies),<sup>25–31,33–36,38–45,47,48,50–55,59,61–63</sup> three ( $n=4$  studies)<sup>32,37,56,57</sup> or four study ( $n=2$  studies)<sup>46,58</sup> arms. The



**FIGURE 1** Systematic literature review Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of selected articles.

two non-randomised control trials each had two study arms.<sup>49,60</sup> Study populations included adults with cardiovascular disease (CVD) ( $n = 16$  studies),<sup>25,27,29–31,33,35,37,39,40,43,48,50,53,60,62</sup> Type 2 DM ( $n = 13$  studies),<sup>26,32,41,42,44,45,52,55,58,59,61,63</sup> unspecified DM ( $n = 1$  study),<sup>38</sup> obesity ( $n = 4$  studies),<sup>46,49,56,57</sup> CKD ( $n = 3$  studies)<sup>28,51,54</sup> and combined population group ( $n = 2$ ).<sup>34,47</sup> The duration of the studies ranged from eight weeks to 24 months. Studies were conducted across 20 different countries, 60% of which were high income.<sup>27–32,34,35,37,39,40,42,44–51,54,56,58,61–63</sup> Dietary education predominately included tailored or general advice on healthy eating, dietary patterns (i.e., Mediterranean diet and dietary approaches to stop hypertension) or specific nutrients (i.e., sodium restriction). A range of digital health tools was used in these interventions, internet ( $n = 17$  studies),<sup>29–32,34–37,40,47,48,50,51,57–59,63</sup> including apps and/or messaging systems ( $n = 16$  studies),<sup>25–28,41–44,46,49,52–54,56,60,62</sup> electronic software ( $n = 1$  study)<sup>45</sup> or combination of these methods ( $n = 5$  studies).<sup>33,38,39,55,61</sup> The control groups were provided usual care that did include nutrition or lifestyle counselling, printed educational resources, online articles or e-mailed newsletter (but with no tailored dietary information). Most of the studies ( $n = 33$  studies)<sup>25–27,29–32,34–49,51–53,55–61,63</sup> involved other lifestyle components in addition to diet (Table 1).

## Digital health effect on dietary intake

### Diet quality scores

Dietary education delivered by digital health may improve overall diet quality scores (SMD = 0.37, CI =  $-0.08$  to  $0.82$ ,  $p = 0.11$ ,  $I^2 = 95\%$ ); however, the 95% CI included the possibility of no change (Figure 2). Digital health interventions did, however, significantly increase the Mediterranean diet adherence score (SMD = 0.79; 95% CI =  $0.18$  to  $1.40$ ;  $p = 0.01$ ;  $I^2 = 92\%$ ) in three pooled studies ( $n = 642$  participants)<sup>26,27,33</sup> (Figure 2). Re-expressing this SMD value using a weight average across all included studies for this outcome resulted in an approximate MD of 1.3 points. Six studies on diet quality scores could not be included in the meta-analysis because of variations in statistical reporting and have been narratively reported in the Supporting information (Table S2).<sup>25,28,34,40,47,54</sup> One of these studies reported significant improvements to diet quality scores as a result of digital health when compared to the control group.

### Fruit and vegetable intake

Digital health interventions significantly improved overall fruit and vegetable intake (MD = 0.63 servings/day, 95% CI =  $0.27$  to  $0.98$ ,  $p = 0.0006$ ,  $I^2 = 65\%$ ) (Figure 3).

Furthermore, for studies that measured fruit intake alone, a statistical increase was found as result of digital health (MD = 0.58 servings/day; 95% CI =  $0.39$  to  $0.77$ ;  $p < 0.00001$ ;  $I^2 = 0\%$ ) in four pooled studies ( $n = 433$  participants).<sup>37,45,48,54</sup> Results remained statistically significant for three trials ( $n = 388$  participants)<sup>37,48,54</sup> that were  $< 12$  months of follow-up (MD = 0.60 servings per day; 95% CI =  $0.40$  to  $0.80$ ;  $p < 0.00001$ ;  $I^2 = 0\%$ ). Meta-analysis of three studies that reported on vegetable intake alone ( $n = 235$  participants)<sup>37,45,54</sup> found no statistical difference (MD = 0.68 servings/day; 95% CI =  $-0.30$  to  $1.65$ ;  $p = 0.17$ ;  $I^2 = 72\%$ ). Similarly, no changes were found in three pooled studies ( $n = 603$  participants)<sup>46,50,57</sup> that reported on a combined measure of fruit and vegetable intake (MD = 0.81 servings/day; 95% CI =  $-0.82$  to  $2.44$ ;  $p = 0.33$ ;  $I^2 = 88\%$ ). As a result of the varying measures of fruit and vegetable intake, several studies could not be included in the meta-analysis and have been included in the Supporting information (Table 2).<sup>26,30,34,38,39,49,52,53,61</sup> Twenty-two percent of these studies showed a significant increase in fruit and/or vegetable intake as a result of digital health compared to the control group.

### Sodium intake

Meta-analysis of seven studies ( $n = 993$  participants)<sup>28,33,34,46,48,54,62</sup> found digital health interventions did result in a significant reduction in sodium intake (SMD =  $-0.22$ ; 95% CI =  $-0.44$  to  $-0.01$ ;  $p = 0.04$ ;  $I^2 = 59\%$ ). Three studies<sup>43,51,53</sup> reported varying measures of sodium intake (e.g., urine salinity or adherence of salt intake) and could not be included in the meta-analysis; two of the three studies reported significant differences favouring digital health interventions over the control group (see Supporting information, Table S2).

### Energy intake

Meta-analysis of five studies ( $n = 880$  participants)<sup>33,34,41,46,54</sup> that reported on energy intake found no effect (MD =  $-4.44$  kilocalories/day; 95% CI =  $-105.42$  to  $96.54$ ;  $p = 0.93$ ;  $I^2 = 33\%$ ). One study<sup>44</sup> that demonstrated a reduction in energy intake in intervention compared to the control group could not be included in the meta-analysis because the measure of energy intake was inconsistent with the other studies (see Supporting information, Table S2).

### Fat intake

Five studies ( $n = 1149$  participants)<sup>32,33,35,41,58</sup> reporting on total fat intake were meta-analysed and found no

TABLE 1 Summary of characteristics and main findings

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
<b>Hospital-based settings</b>				
Akhu-Zaheya and Shiyab, <sup>25</sup> Jordan; 3 months of follow-up	<i>n</i> = 180; 54.9 years; CVD	Mobile SMS; 3 × SMS in total educating on a healthy diet; 3 months; dietitian; SMSs related to medication and smoking cessation	Usual care	↑MEDAS* ( <i>p</i> < 0.050) * A score up to 13 points was reported, whereas MEDAS usually has 14 points
Alonso-Dominguez et al., <sup>26</sup> Spain; 12 months of follow-up	<i>n</i> = 204; 60.6 years; DM (type 2)	Mobile app: Access to detailed information on nutritional deviations provided based on documented intake; 3 months; dietitian; 90 min workshop on Mediterranean diet, walking once/week × 5 weeks, group walks	Usual care (brief advice on health eating provided of 5 min)	↑MEDAS ( <i>p</i> < 0.001); ↑HbA1c ( <i>p</i> = 0.241); #TC (mg/dL) ( <i>p</i> = 0.823); #HDL-C (mg/dL) ( <i>p</i> = 0.927); #LDL-C (mg/dL) ( <i>p</i> = 0.973); #SBP (mmHg) ( <i>p</i> = 0.678); #DBP (mmHg) ( <i>p</i> = 0.227); #WC (cm) ( <i>p</i> = 0.390)
Choi et al., <sup>27</sup> United States; 6 months of follow-up	<i>n</i> = 100; 57.9 years; CVD	Mobile app: Access to weekly challenges to encourage diet modifications, dietitian or participant could initiate contact through app, could document and take photos of intake; 3 months; dietitians; PA and BP could be recorded	Usual care (brief dietary counselling via telephone)	↓BMI (kg/m <sup>2</sup> ) ( <i>p</i> = 0.030); ↓Weight (kg) ( <i>p</i> = 0.040); #MEDAS ( <i>p</i> = 0.470); #SBP (mmHg) ( <i>p</i> = 0.340); #DBP (mmHg) (0.270); #HDL-C (mg/dL) ( <i>p</i> = 0.120); #LDL-C (mg/dL) ( <i>p</i> = 0.580); #TG (mg/dL) ( <i>p</i> = 0.71); #VLDL-C (mg/dL) ( <i>p</i> = 0.710); #TC (mg/dL) ( <i>p</i> = 0.900); #HbA1c (%) ( <i>p</i> = 0.450)
Dawson et al., <sup>28</sup> Australia, 6-months of follow-up	<i>n</i> = 130; 64.8 years; CKD (haemodialysis)	Mobile SMS; 3 × SMS per week with information to improve renal dietary behaviours, unidirectional and semi-personalised; 6 months; dietitians	Usual care (standard dietary care)	↓Protein (g/day) ( <i>p</i> = 0.020); ↓Sodium (mg/day) ( <i>p</i> = 0.020); ↓Potassium (mmol/day) ( <i>p</i> = 0.010); ↓Phosphate (mg/day) ( <i>p</i> = 0.003); ↑Health Eating Index ( <i>p</i> = 0.300); ↑EQ-5D ( <i>p</i> = 0.03); ↓Interdialytic weight gain (kg/session) ( <i>p</i> = 0.02); #HbA1c (%) ( <i>p</i> = 0.200) #Meeting serum phosphate guidelines ( <i>p</i> = 0.200); #Meeting serum potassium guidelines ( <i>p</i> = 0.500); #Postdialysis SBP (mmHg) ( <i>p</i> = 0.700); # Postdialysis DBP (mmHg) ( <i>p</i> = 0.300)
Devi et al., <sup>29</sup> United Kingdom (UK); 6-months of follow-up	<i>n</i> = 95 (started); 66.2 years; CVD (angina)	Internet-based: Access to BCTs, tailored goals and recognition of goal achievement; tailored dietary information; 6 weeks; dietitian and cardiac nurses; written information about health consequences and other lifestyle factors	Usual care	↓Weight (kg) ( <i>p</i> = 0.020); ↓SBP (mmHg) ( <i>p</i> = 0.003); ↑Self-efficacy ( <i>p</i> = 0.030); ↑QOL emotional score ( <i>p</i> = 0.040); #Fibre score ( <i>p</i> = 0.550); #Fat score ( <i>p</i> = 0.500); #Body fat (%) ( <i>p</i> = 0.490); #DBP ( <i>p</i> = 0.970); #QOL social score ( <i>p</i> = 0.340); #QOL physical score ( <i>p</i> = -0.620)
Duan et al., <sup>30</sup> Hong Kong, 8 weeks of follow-up	<i>n</i> = 114; 49.2 years; CVD (coronary heart disease)	Internet-based: Access to 4 modules (including a fruit and vegetable intake module); 8 weeks; nurses; PA module	Usual care (waitlist control)	↑Fruit and vegetable intake (portions/day) ( <i>p</i> < 0.0010); ↑Self-efficacy ( <i>p</i> < 0.001); ↑QoL ( <i>p</i> < 0.001); #BMI (kg/m <sup>2</sup> ) ( <i>p</i> = 0.070)

(Continues)

TABLE 1 (Continued)

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
Engelen et al., <sup>31</sup> the Netherlands, 12 months of follow-up	<i>n</i> = 208; 63.5 years; CVD	Internet-based: Access to modules with 6 topics (including healthy nutrition; quotes, tailored feedback and written information), diet diary, videos of patients with CVD; 12 months; health professionals (not defined); PA module	Usual care (included feedback to optimise lifestyle)	<p>‡DHD score (<math>p = 0.720</math>); †Weight (kg) (<math>p = &gt;0.050</math>); †HDL-C (mmol/L) (<math>p &gt; 0.050</math>); †LDL-C (mmol/L) (<math>p &gt; 0.050</math>); †SBP (mmHg) (<math>p &gt; 0.050</math>); †DBP (mmHg) (<math>p &gt; 0.05</math>); †TG (mmol/L) (<math>p &gt; 0.050</math>); †TC (mmol/L) (<math>p &gt; 0.050</math>); †Self-efficacy for diet score (<math>p = 0.750</math>)</p>
Glasgow et al., <sup>32</sup> United States, 12 months of follow-up	<i>n</i> = 475; 58.4 years; DM (type 2)	Internet-based: Access to clinical measures, a moderated forum, resources (including recipes and handouts), quiz questions and motivational tips, ability to record progress of goals (including diet); 12 months; dietitian; PA and medication action planning	Usual care (no nutritional advice provided)	<p>CASM &amp; CASM+ compared to control group</p> <p>‡Healthy Eating Habits Score (<math>p &lt; 0.050</math>); †Fat intake (%) (<math>p &lt; 0.050</math>); †HbA1c (%) (<math>p &gt; 0.050</math>); †BMI (kg/m<sup>2</sup>) (<math>p &gt; 0.050</math>); †Self-efficacy (<math>p &gt; 0.050</math>)</p>
*Note 2 intervention groups:				
1. Computer assisted self-management (CASM)				
E2. Computer assisted self-management and enhanced social support (CASM+)				
Groni et al., <sup>33</sup> Spain, 24 months of follow-up	<i>n</i> = 720; 59.7 years; CVD (atrial fibrillation)	Internet-based and mobile app: Access to 6 modules (including advice, practical tips and the Mediterranean diet classroom); 24 months; dietitian and medical doctor	Usual care	<p>‡Fruit intake (g/day) (<math>p &lt; 0.001</math>); †Sodium intake (mg/day) (<math>p &lt; 0.001</math>); †Fibre intake/day (<math>p &lt; 0.001</math>); †Omega 3 intake (mg/day) (<math>p &lt; 0.001</math>); †SFA (<math>p &lt; 0.001</math>); †Other alcoholic drinks intake (g of alcohol/day) (<math>p = 0.030</math>); †Sweets consumption (g/week) (<math>p &lt; 0.001</math>); †Virgin olive oil intake (g/day) (<math>p &lt; 0.001</math>); †Other fats than olive oil intake (g/day) (<math>p = 0.050</math>); †Red processed meat intake (g/week) (<math>p &lt; 0.001</math>); †Fatty fish intake (g/week) (<math>p &lt; 0.001</math>); †White fish intake (g/week) (<math>p &lt; 0.001</math>); †Nuts (g/week) (<math>p &lt; 0.001</math>); †Pulses intake (g/day) (<math>p = 0.002</math>); †Refined cereals intake (g/day) (<math>p &lt; 0.001</math>); †Carbohydrates intake (g/day) (<math>p = 0.020</math>); †Vegetables intake (g/day) (<math>p = 0.060</math>); †Protein intake (g/day) (<math>p = 0.700</math>); †Polyunsaturated fats intake (g/day) (<math>p = 0.150</math>); †Monounsaturated fats intake (g/day) (<math>p = 0.720</math>); †Fat intake (g/day) (<math>p = 0.700</math>); †Energy intake (kcal/day) (<math>p = 0.080</math>); †Eggs consumption (<math>p = 0.070</math>);</p>

TABLE 1 (Continued)

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
Hansel et al., <sup>34</sup> France; 16 weeks of follow-up	<i>n</i> = 120; 57.0 years; obesity and DM (type 2)	Internet-based: Access to 4 modules (including diet self-monitoring module, nutritional assessment module, balanced diet menu generator module), personalised menus and a shopping list for the day or the week available; 16 weeks; dietitian; PA education and prescription	Usual care	<p>≠Dairy products (g/week) (<i>p</i> = 0.100); ≠Red wine consumption (g of alcohol/day) (<i>p</i> = 0.27);</p> <p>↑ DQI-I score (<i>p</i> &lt; 0.001); ↓Body weight (kg) (<i>p</i> = 0.010); ↓WC (cm) (<i>p</i> = 0.010); ↓HbA1c (%) (<i>p</i> &lt; 0.001); ↓Lipids intake (g/day) (<i>p</i> = 0.020); ↓Saturated fat intake (g/day) (<i>p</i> &lt; 0.001); ≠Energy intake (kcal/day) (<i>p</i> = 0.110); ≠Fibre intake (g/day) (<i>p</i> = 0.160); ≠Carbohydrates intake (g/day) (<i>p</i> = 0.080); Sodium intake (mg/day) (<i>p</i> = 0.070); ≠Proteins intake (g/day) (<i>p</i> = 0.870); ≠Calcium intake (mg/day) (<i>p</i> = 0.310); ≠TG (mg/dl) (<i>p</i> = 0.670); ≠LDL-C (mg/dl) (<i>p</i> = 0.430); ≠HDL-C (mg/dl) (<i>p</i> = 0.780); ≠TC (mg/dl) (<i>p</i> = 0.400); FBG (mmol/L) (<i>p</i> = 0.360)</p>
Lear et al., <sup>35</sup> Canada, 16 months of follow-up	<i>n</i> = 78; 60 years; CVD	Internet-based: 3× one-on-one chat sessions with health professionals, weekly education sessions in the form of interactive slide presentations, monthly ask-an-expert group chat sessions to discuss progress; 16 weeks; dietitian, nurse and exercise specialist; PA prescription, wore heart rate monitors and data uploaded	Usual care	<p>↑Protein intake (% kcal/day) (<i>p</i> = 0.044);</p> <p>↓Saturated fat intake (% kcal/day) (<i>p</i> = 0.018);</p> <p>↓TC (mmol/L) (<i>p</i> = 0.026); ↓LDL (mmol/L) (<i>p</i> = 0.022); ≠Fat intake (% kcal/day) (<i>p</i> = 0.451); ≠Carbohydrate intake (% kcal/day) (<i>p</i> = 0.224); ≠Major events including death (<i>p</i> = 0.480); ≠HDL-C (mmol/L) (<i>p</i> = 0.075); ≠TG (mmol/L) (<i>p</i> = 0.715); ≠Blood pressure (mmHg) (<i>p</i> = 0.051); ≠FBG (mmol/L) (<i>p</i> = 0.592); ≠BMI (kg/m<sup>2</sup>) (<i>p</i> = 0.242); ≠WC (cm) (<i>p</i> = 0.242)</p>
Liang et al., <sup>36</sup> China, 6 months of follow-up	<i>n</i> = 300; 54.9 years; DM (type 2)	Internet-based: Communicated with doctors to receive dietary feedback and education and involved a chat feature; 6 months; medical doctors, nurses and nutritionists; PA and medication education and prescription	Usual care	<p>↑Diet compliance rate (<i>p</i> &lt; 0.01); BMI (kg/m<sup>2</sup>) (<i>p</i> = &lt; 0.001); ↓WC (cm) (<i>p</i> &lt; 0.001); ↓SBP (mmHg) (&lt; 0.001); ↓TG (mmol/L) (<i>p</i> = &lt; 0.001); ↓LDL-C (mmol/L) (<i>p</i> &lt; 0.001); ≠TC (mmol/L) (<i>p</i> = 0.901); ≠HbA1c (%) (<i>p</i> = 0.809); ≠HDL-C (mmol/L) (<i>p</i> = 0.561)</p>
Liu et al., <sup>37</sup> Canada, 4 months of follow-up	<i>n</i> = 128; 56.9 years; CVD (hypertension)	Internet-based: Weekly emails imbedded text information and video web links with predetermined diary goals; 6 months; Canadian Food guide, Canadian Hypertension Education Program and Canadian Physical Activity guidelines; PA goals and education	Usual care (weekly email newsletter on hypertension management)	<p><i>Control versus User driven group:</i></p> <p>↑Fruit intake (servings/day) (<i>p</i> = 0.010); ↓TC (mmol/L) (<i>p</i> &lt; 0.010); ↓SBP (mmHg) (<i>p</i> &lt; 0.010)</p>

(Continues)



TABLE 1 (Continued)

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
		<p>*Note 2 intervention groups:</p> <p>1. <i>User driven group (Internet-based self-management with choice of lifestyle goals)</i></p> <p>2. <i>Expert driven group (Internet-based prescribed lifestyle goals)</i></p>		
Patnaik et al., <sup>38</sup> India, 3 months of follow-up	<i>n</i> = 100; 54 years; DM (not specified, gestational diabetes was excluded)	Internet-based and Mobile SMS: Access to online lifestyle education, weekly SMS related to diet; 3 months; endocrinologist; contacted by investigator every 3 weeks (asked about lifestyle change and counselled), printed education, SMS related to PA and medication	Usual care (printed educational materials)	<p>No significant difference between control versus expert group: #Fruit intake (servings/day) (<math>p = 0.920</math>); #SBP (mmHg) (<math>p = 0.140</math>); #TC (mmol/L) (<math>p = 0.110</math>)</p> <p>#Fried food intake (servings/week) (<math>p = 0.053</math>); #Sweets intake (servings/day) (<math>p = 0.070</math>); #Sugar intake (teaspoons/day) (<math>p = 1.000</math>); #Fish intake (servings/week) (<math>p = 0.180</math>); #Fruit intake (servings/day) (<math>p = 0.140</math>); #Soft drink intake (ml/week) (<math>p = 0.380</math>); *<i>p</i> values missing for vegetable intake (servings/day) and FBG (mg/dL)</p>
Pfaeffli et al., <sup>39</sup> New Zealand, 6 months of follow-up	<i>n</i> = 123; 59.5 years; CVD (coronary heart disease)	Internet-based and Mobile SMS: 7 × SMS/week and access to a support website with diet-related tips, blogs and videos; 24 weeks; medical professionals; PA and smoking advice	Usual care	<p>↓LDL (mmol/L) (<math>p = 0.053</math>); #BMI (kg/m<sup>2</sup>) (<math>p = 0.660</math>); #SBP (mmHg) (<math>p = 0.980</math>); #DBP (mmHg) (<math>p = 0.900</math>); #TC (mmol/L) (<math>p = 0.080</math>); #HDL-C (mmol/L) (<math>p = 0.510</math>); #Self-efficacy (<math>p = 0.730</math>) *<i>p</i> values missing for adherence of fruit and vegetables and non-harmful alcohol intake</p>
Southard et al., <sup>40</sup> United States, 6 months of follow-up	<i>n</i> = 104; 62.3 years; CVD	Internet-based: Access to website (asked to log in once/wk for 30 min), communicated with case manager, online group discussion where they could contact other participants, links to related sites, interactive education module (multichoice and self-tests), dietary feedback; 6 months; dietitians; PA education and record kept	Usual care	<p>↓Weight (lb) (<math>p = 0.003</math>); ↓BMI (kg/m<sup>2</sup>) (<math>p = 0.003</math>); #MEDFICTS score (<math>p &gt; 0.050</math>)*; #SBP (mmHg) (<math>p &gt; 0.050</math>); #DBP (mmHg) (<math>p &gt; 0.050</math>); #LDL-C (mg/dL) (<math>p &gt; 0.050</math>); #HDL-C (mg/dl) (<math>p &gt; 0.050</math>); #TG (mg/L) (<math>p &gt; 0.050</math>); #TC (mg/dL) (<math>p &gt; 0.050</math>); #QoL (all components) (<math>p &gt; 0.050</math>)</p>
Vinitha et al., <sup>41</sup> India, 24 months of follow-up	<i>n</i> = 248; 43.3 years; DM (type 2)	Mobile SMS: 2–3 SMS/wk reinforcing health lifestyle practice and diabetes management (including diet-related text messages); 24 months; medical doctors; interviewed by trained personnel to advise individual level behaviour change, SMS related to PA and medication	Usual care	<p>↓SBP (mmHg) (<math>p = 0.007</math>); ↓HBA1C (%) (<math>p = 0.044</math>); #Carbohydrate intake (g/day) (<math>p = 0.172</math>); #Fat intake (g/day) (<math>p = 0.833</math>); #Fibre intake (g/day) (<math>p = 0.619</math>); #Energy intake (kcal/day) (<math>p = 0.269</math>); #Protein intake (g/day) (<math>p = 0.933</math>); #DBP (mmHg) (<math>p = 0.909</math>); #HDL-C (mmol/L) (<math>p = 0.605</math>); #LDL-C (mmol/L) (<math>p = 0.222</math>); #TC (mmol/L) (<math>p = 0.421</math>); #TG (mmol/L) (<math>p = 0.565</math>); #EQ. 5D QoL (<math>p = 0.725</math>); #Weight (kg) (<math>p = 0.861</math>);</p>

TABLE 1 (Continued)

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
Waki et al., <sup>42</sup> Japan, 3 months of follow-up	<i>n</i> = 54; 57.3 years; DM (type 2)	Mobile app + SMS; access to 4 modules, could voice or SMS about meals, received dietary evaluation and advice; 3 months; dietitians; PA advice	Usual care	<p> <math>\neq</math>BM (<math>\text{kg/m}^2</math>) I (<math>p = 0.434</math>); <math>\neq</math>WC (cm) (<math>p = 0.922</math>)         </p> <p> <math>\downarrow</math>HbA1c (%) (<math>p = 0.015</math>); <math>\downarrow</math>FBG (mg/dl) (<math>p = 0.019</math>); <math>\neq</math>SDSCA-diet component (<math>p = 0.480</math>); <math>\neq</math>SBP (mmHg) (<math>p = 0.400</math>); <math>\neq</math>DBP (mmHg) (<math>p = 0.350</math>); <math>\neq</math>BMI (<math>\text{kg/m}^2</math>) (<math>p = 0.062</math>); <math>\neq</math>ITG (mg/dl) (<math>p = 0.240</math>); <math>\neq</math>HDL-C (mg/dl) (<math>p = 0.360</math>); <math>\neq</math>LDL-C (mg/dl) (<math>p = 0.430</math>);         </p> <p> <math>\uparrow</math>Low-salt diet consumption (<math>p = 0.002</math>); <math>\uparrow</math>Nutrition (<math>p &lt; 0.001</math>); <math>\downarrow</math>SBP (mmHg) (<math>p = 0.004</math>); <math>\downarrow</math>DBP (mmHg) (<math>p = 0.043</math>); Limiting alcohol use (<math>p = 0.548</math>)         </p>
Wan et al., <sup>43</sup> China, 3 months of follow-up	<i>n</i> = 174; 59% 60–86 years, 19% 45–59 years, <5% 35–44 years; CVD (stroke)	Mobile SMS: Weekly SMS reminders on lifestyle modifications and health beliefs (derived from the educational handbook provided at discharge); 3 months; nurses; F2F and telephone education, SMS related to medication adherence	Usual care	<p> <i>Within the intervention group between baseline and end of study</i>*: <math>\uparrow</math>Adherence to carbohydrate intake (<math>p &lt; 0.001</math>); <math>\uparrow</math>Adherence to total kilocalorie intake (<math>p &lt; 0.001</math>); <math>\uparrow</math> adherence to fruit intake (<math>p &lt; 0.001</math>); <math>\neq</math>Adherence to fat intake (<math>p = 0.072</math>); <math>\neq</math>Adherence to protein intake (<math>p = 0.158</math>)         </p> <p> <i>Within the control between baseline and end of study</i>*: <math>\neq</math>Adherence to Carbohydrate intake (<math>p = 0.409</math>); <math>\neq</math> Adherence to total kilocalorie intake (<math>p = 0.187</math>); <math>\neq</math>Adherence to fruit intake (<math>p = 0.260</math>); <math>\neq</math>Adherence to fat intake (<math>p = 0.162</math>); <math>\neq</math>Adherence to protein intake (<math>p = 0.560</math>)         </p> <p> <i>*No between-group analysis conducted</i> </p>
Yasmin et al., <sup>44</sup> Germany, 2 months of follow-up	<i>n</i> = 320; 52.0 years; DM (type 2)	Mobile interactive voice call: Personalised reminders on dietary advice; 2 months; medical doctors; PA and medication reminders	Usual care	<p> <i>Within the intervention group between baseline and end of study</i>*: <math>\uparrow</math>Adherence to carbohydrate intake (<math>p &lt; 0.001</math>); <math>\uparrow</math>Adherence to total kilocalorie intake (<math>p &lt; 0.001</math>); <math>\uparrow</math> adherence to fruit intake (<math>p &lt; 0.001</math>); <math>\neq</math>Adherence to fat intake (<math>p = 0.072</math>); <math>\neq</math>Adherence to protein intake (<math>p = 0.158</math>)         </p> <p> <i>Within the control between baseline and end of study</i>*: <math>\neq</math>Adherence to Carbohydrate intake (<math>p = 0.409</math>); <math>\neq</math> Adherence to total kilocalorie intake (<math>p = 0.187</math>); <math>\neq</math>Adherence to fruit intake (<math>p = 0.260</math>); <math>\neq</math>Adherence to fat intake (<math>p = 0.162</math>); <math>\neq</math>Adherence to protein intake (<math>p = 0.560</math>)         </p> <p> <i>*No between-group analysis conducted</i> </p>
<i>Community-based programmes</i>				
Abu-Saad et al., <sup>45</sup> Israel, 12 months of follow-up	<i>n</i> = 50; 53.0 years, DM (type 2)	Electronic software: Designed for dietitian use with clients and allows calculation of food intake, enables uploading and modification of educational material, tailors and prioritises education, documents consultation; data is summarised and compared to evidence-based food and goals; 12 months; dietitians; PA education and advice	Usual care	<p> <math>\downarrow</math>Added sugar intake (%) of total energy (<math>p = 0.050</math>); <math>\neq</math>Fibre intake (g/1000 kcal) (<math>p = 0.580</math>); <math>\neq</math>Fruit intake (portions/day) (<math>p = 0.200</math>); <math>\neq</math>Vegetables intake (portions/day) (<math>p = 0.170</math>); <math>\neq</math>Wholegrains intake (portions/day) (<math>p = 0.330</math>)         </p>

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TABLE 1 (Continued)

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
Allen et al., <sup>46</sup> United States, 6 months of follow-up	<i>n</i> = 63; 44.9 years; obesity	Mobile app: Promoted self-management and mindful empowerment; document food intake and provided real-time feedback of energy balance with helpful charts and graphs, opportunity for social networking and support; 6 months; nutritionist; in person nutrition counselling related to decreasing calories and following DASH diet, goals and counselling also related to PA	Usual care	Between all intervention groups and control group: #Energy intake (kcal/day) ( <i>p</i> = 0.660); #Fruit/vegetable intake (servings/day) ( <i>p</i> = 0.610); #Sodium intake (mg/day) ( <i>p</i> = 0.880); #Weight (kg) ( <i>p</i> = 0.890); #Male WC (cm) ( <i>p</i> = 0.360); #Female WC (cm) ( <i>p</i> = 0.22); #BMI ( <i>p</i> = 0.790); #Calories from fat (%) ( <i>p</i> = 0.370)
		*Note 3 intervention groups: 1. Intensive counselling + mobile app 2. Less intensive counselling + mobile app 3. Mobile app only		
Azar et al., <sup>47</sup> United States; 6 months of follow-up	<i>n</i> = 74; 59.7 years; Obesity, CVD and or DM (type 2)	Internet-based: Online platform and participant portal with programme materials (homework, videos, calendar and educational resources); 6 months; medical doctors, nutritionists and exercise physiologists; included F2F group and individual sessions via video conference, portable and or wearable mobile devices, included data collection (e.g., fit bit and wireless scale)	Usual care (wait-list)	↓BMI (kg/m <sup>2</sup> ) ( <i>p</i> = <0.050); #Weight (kg) ( <i>p</i> > 0.050); #DASH score ( <i>p</i> > 0.05); #SBP (mmHg) ( <i>p</i> > 0.050); #DBP (mmHg) ( <i>p</i> > 0.050); #HDL-C (mg/dL) ( <i>p</i> > 0.050); #LDL-C mg/dL) ( <i>p</i> > 0.050); #TC (mg/dl) ( <i>p</i> > 0.050); #TG ( <i>p</i> > 0.050); SF-8 mental ( <i>p</i> > 0.050); SF-8 physical component ( <i>p</i> > 0.050)
Cicolini et al., <sup>48</sup> Italy, 6 months of follow-up	<i>n</i> = 203; 58.3 years; CVD (hypertension)	Internet-based: 1 × email/mo. related to healthy lifestyle compliance, advice on (diet rich in vegetables and low in salt, saturated fat and cholesterol); 6 months; nurse; usual care, phone calls and emails relating to other lifestyle factors	Usual care	↑Fruit intake (servings/day) ( <i>p</i> < 0.001); ↓BMI (kg/m <sup>2</sup> ) ( <i>p</i> < 0.001); ↓SBP ( <i>p</i> < 0.001); DBP (mmHg) ( <i>p</i> < 0.001); ↓LDL-C (mg/dL) ( <i>p</i> < 0.001); ↓TC (mg/dL) ( <i>p</i> < 0.001); ↓Alcohol intake (units of alcohol/day) ( <i>p</i> = 0.038); #TG ( <i>p</i> = 0.120); #Salt intake (teaspoons/day) ( <i>p</i> = 0.400); #FBG (mg/dl) ( <i>p</i> = 0.900)
Donaldson et al., <sup>49</sup> United Kingdom, 12 weeks of follow-up	<i>n</i> = 34; 58.3 years; obesity <sup>a</sup>	Mobile SMS: Participant sent self-monitored data to practitioner related to meeting targets for fruit and vegetables, breakfast consumption; received individualised response from practitioner congratulating them on meeting target or encouraging tips to improve; 12 weeks; dietitian; PA pedometer and step target	Usual care	↓Weight (kg) ( <i>p</i> = 0.006); ↓WC (cm) ( <i>p</i> = 0.001); ↓BMI (kg/m <sup>2</sup> ) ( <i>p</i> = 0.030); #Fruit and vegetables intake (portions/day) ( <i>p</i> = 0.249); #Breakfast consumption (0.317); #Impact of Weight on Quality of Life tool (IWQOL) ( <i>p</i> = 0.134)
Green et al., <sup>50</sup> United States, 6 months of follow-up	<i>n</i> = 101; 56.9 years; CVD (hypertension)	Internet-based: DASH diet education; sharing of self-monitored data through the web-portal; dietitian responded to questions via a messaging system,	Usual care	↑Fruit and vegetable intake (servings/day) (<0.010); ↓Weight (kg) (<0.001); ↑Weight loss ≥4 kg ( <i>p</i> = 0.020); #SBP (mmHg) ( <i>p</i> = 0.400);

TABLE 1 (Continued)

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
Humalda et al., <sup>51</sup> the Netherlands, 9 months of follow-up	$n = 99$ ; 56.6 years; CKD	Internet-based: Access to modules for restricting sodium intake, food diary; 3 months +6 months maintenance phase; dietitians, nurses and certified lifestyle professionals; coaching sessions F2F in 3 months and email in 6 months maintenance), PA module	Usual care	<p>±DBP (mmHg) (<math>p = 0.320</math>); ±TC (mg/dl) (<math>p = 0.520</math>); ±HDL-C (mg/dL) (<math>p = 0.240</math>); ±LDL-C (mg/dL) (<math>p = 0.710</math>); ±HbA1c (%) (<math>p = 0.110</math>); ±Obesity and weight loss quality of life (<math>n = 0.140</math>); ±FBG (mg/dL) (<math>p = 0.860</math>), ±WC (inches) (<math>p = 0.600</math>)</p> <p>↑SF-12 Mental component (<math>p = 0.010</math>); ↑SF-12 Physical component (<math>p = 0.010</math>); ±Na (mmol/24 h) (<math>p &gt; 0.050</math>); ±SBP (mmHg) (<math>p &gt; 0.050</math>); ±DBP (mmHg) (<math>p &gt; 0.050</math>)</p>
Islam et al., <sup>52</sup> Bangladesh, 6 months of follow-up	$n = 236$ ; 48.1 years; DM (type 2)	Mobile (SMS); 1× SMS/day related to diet and BCT; 6 months; GP, endocrinologist and nurse; SMS related to other lifestyle factors	Usual care	<p>↓Spoons of sugar in tea/coffee intake (<math>p &lt; 0.050</math>); ±Fruit intake (servings/week) (<math>p &gt; 0.050</math>); ±Sugary beverages intake (servings/week) (<math>p &gt; 0.050</math>); ±Vegetables intake (servings/week) (<math>p &gt; 0.050</math>)</p>
Jahan et al., <sup>53</sup> Bangladesh, 5 months of follow-up	$n = 420$ ; 47.1 years; CVD (hypertension)	Mobile SMS: 21× SMS (5 in first months and once/week in the last 4 months) developed in accordance with DASH diet and other guidelines (awareness, knowledge and motivate for behaviour change); 5 months; National Institute of Health and WHO guidelines; in person education and booklet provided, SMSs related to PA	Usual care (education booklet and in person follow-up visits every months)	<p>↑Adherence to salt intake (<math>p = 0.040</math>); ↓SBP (mmHg) (<math>p = 0.040</math>); ↓DBP (mmHg) (<math>p = 0.020</math>); ↑QoL (<math>p &lt; 0.001</math>); ± Adherence to fruit intake (<math>p = 0.680</math>); ±Adherence to vegetable intake (<math>p = 0.250</math>)</p>
Kelly et al., <sup>54</sup> Australia, 6 months of follow-up	$n = 80$ ; 62 years; CKD (Stage 3–4)	Mobile SMS: weekly SMS to remind on set goals, provide health eating education and prompt self-monitoring; 6 months; dietitians; workbook and telephone coaching (Phase 1, first 3 months)	Usual care (delayed contact for 3 months and provided an education workbook)	<p><i>Within the intervention group between baseline and 3 months:</i> ↑Alternative Healthy Eating Index (<math>p \leq 0.050</math>); ↑Fruit intake (servings/day) (<math>p \leq 0.001</math>); ↑Vegetable intake (servings/day) (<math>p \leq 0.0001</math>); QoL (<math>p \leq 0.05</math>); ↑Fibre (g/day) (<math>p &lt; 0.05</math>); Sodium (<math>p &lt; 0.05</math>); ↓Weight (kg) (<math>p &lt; 0.05</math>); ↓WC (cm) (<math>p &lt; 0.05</math>); ±Energy (kJ) (<math>p &gt; 0.05</math>); ±Protein (g) (<math>p &gt; 0.05</math>); ±SBP (mmHg) (<math>p &gt; 0.05</math>); ±DBP (mmHg) (<math>p &gt; 0.05</math>)</p> <p><i>Within the control between baseline and end of 3 months:</i></p> <p>↓Sodium (<math>p &gt; 0.05</math>); ↓Energy (<math>p &gt; 0.05</math>); ↓Protein (<math>p &gt; 0.05</math>); ±Fibre (<math>p &lt; 0.05</math>); ±WC (<math>p &gt; 0.05</math>); ±DBP (mmHg) (<math>p &gt; 0.05</math>)</p>

(Continues)

TABLE 1 (Continued)

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
Ku et al., <sup>55</sup> Korea, 12 weeks of follow-up	<i>n</i> = 40; 50 years; DM (type 2)	Internet-based, mobile app and SMS: received feedback via SMS related to their dietary assessment, access to internet programme with daily entries and social network group activities; 12 weeks; nurse and medical team; PA pedometer and recommend programme	Usual care (conventional diabetes education at baseline)	<p>≠Weight (<math>p &gt; 0.05</math>); ≠QoL (<math>p &gt; 0.05</math>); ≠SBP (<math>p &gt; 0.05</math>); ≠DBP (<math>p &gt; 0.05</math>)</p> <p>↓HbA1c (%) (<math>p = 0.019</math>); ≠SDSCA general diet score (<math>p = 0.870</math>); ≠SDSCA-specific diet score (<math>p = 1.000</math>)</p>
Lewis et al., <sup>56</sup> Australia, 8 months of follow-up	<i>n</i> = 61; 49.5 years; obesity	Mobile SMS: 3 × SMS/week aimed to remind and motivate participants to achieve their goals (tailored from monthly telephone calls and could relate to diet); 8 months; dietitians; monthly motivational telephone calls and SMS related to other lifestyle factors		<p>Time at which Groups 1 and 2 were in the intervention phase compared the time Groups 1 and 2 were in the control phase</p>
		<p>*Note 2 intervention groups (cross-over design):</p> <p>1. Group 1 (TS-C)- Phase 1: 4 months received Telephone and SMS support + Obesity management service (OMS); Phase 2: Control-OMS × 4 months</p> <p>2. Group 2 (C-TS)- Phase 1: Control-OMS alone × 4 months; Phase 2: Telephone and SMS support + Obesity management service (OMS) × 4 months</p>		<p>↑Diet adherence score (<math>p = 0.002</math>); ↑Eating self-efficacy score (<math>p = 0.000</math>); ↓Weight (kg) (<math>p = 0.010</math>); ↑Percentage weight loss (%) (<math>p = 0.010</math>); ↓WC(cm) (<math>p = 0.001</math>); ↓BMI (kg/m<sup>2</sup>) (<math>p = 0.009</math>)</p>
Little et al., <sup>57</sup> Spain, 12 months of follow-up	<i>n</i> = 826; 53.7 years; obesity	Internet-based; 24 web-based session with novel content, links to external content and email reminders, content related to sustainable eating habits and weight management; low-calorie or low-carbohydrate eating plan; 12 months; nurse; PA education	Usual care	<p>Power + F2F compared to control group</p> <p>↑HDL-C (mmol/L) (<math>p = 0.010</math>) ↓Body fat (%) (<math>p = 0.033</math>); ≠Weight (kg) (<math>p = 0.134</math>); ≠HbA1c (mmol/L) (<math>p = 0.192</math>); ≠SBP (mmHg) (<math>p = 0.973</math>); ≠DBP (mmHg) (<math>p = 0.461</math>); ≠LDL (mmol/L) (<math>p = 0.894</math>); ≠TG (mmol/L) (<math>p = 0.826</math>); ≠TC (mmol/L) (<math>p = 0.270</math>); ≠Sweets intake (portions/day) (<math>p = 0.072</math>); ≠Cereal intake (portions/day) (<math>p = 0.072</math>); ≠Fatty foods intake (portions/d) (<math>p = 0.722</math>); ≠Salty snacks intake (portions/d) (<math>p = 0.357</math>); ≠Sweet drinks intake (<math>p = 0.165</math>); ≠Fruit and vegetables intake (portions/day) (<math>p = 0.888</math>); ≠Low-fat dairy intake (portions/day) (<math>p = 0.432</math>);</p>



TABLE 1 (Continued)

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
		<p>*Note 2 intervention groups:</p> <p>1. <i>POWeR + F2F (Internet-based and F2F support)</i></p> <p>2. <i>POWeR + Remote (Internet-based and scheduled phone or email contacts)</i></p>		<p><i>Power + R compared to control group</i></p> <p>↑HDL-C (mmol/L) (<math>p = 0.006</math>); #Weight (kg) (<math>p = 0.134</math>); #HbA1c (mmol/L) (<math>p = 0.213</math>); #SBP (mmHg) (<math>p = 0.061</math>); #DBP (mmHg) (<math>p = 0.979</math>); #LDL (mmol/L) (<math>p = 0.572</math>); #TG (mmol/L) (<math>p = 0.937</math>); #TC (mmol/L) (<math>p = 0.204</math>); #Sweets intake (portions/d) (<math>p = 0.161</math>); #Cereal intake (<math>p = 0.057</math>); #Fatty foods intake (<math>p = 0.270</math>); #Salty snacks intake (portions/d) (<math>p = 0.203</math>); #Sweet drinks intake (portions/d) (<math>p = 0.769</math>); #Fruit and vegetables intake (<math>p = 0.570</math>); #Low-fat dairy intake (portions/d) (<math>p = 0.138</math>); body fat (%) (<math>p = 0.274</math>)</p>
McKay et al., <sup>58</sup> United States, 3 months of follow-up	$n = 160$ ; 59.0 years; DM (type 2)	Internet-based: Online access to a professional dietary coach, interactive online resources based on feedback from dietary assessment; 3 months; professionals with dietary advice; other lifestyle behaviour education	Usual care (access to articles related to nutrition)	<p><i>Both personalised condition compared to control and combined compared to control</i></p> <p>#Block Fat Screener (fat intake) (<math>p &gt; 0.050</math>); #Kristal Fat and Fibre Behaviour Questionnaire; #TC (<math>p &gt; 0.050</math>); #HbA1c (%) (<math>p &gt; 0.050</math>); #SF-12 (<math>p &gt; 0.050</math>)</p>
		<p>*Note 3 intervention groups, 2 involving digital health:</p> <p>1. <i>Personalised self-of management coach condition: website + contact with coach</i></p> <p>2. <i>Combined condition: Resources available in personalised condition and control group</i></p>		
Ramadas et al., <sup>59</sup> Malaysia, 12 months follow-up	$n = 128$ ; 50.5 years; DM (type 2)	Internet-based: 12× personalised dietary lesson plans; tailored advice to address barriers and motivate, encourage to send in queries; email received when new lesson plan uploaded; 12 months; nutritionist	Usual care	<p>↑Total diabetes-related dietary knowledge (<math>p &lt; 0.001</math>), ↑DKAB knowledge score (<math>p &lt; 0.001</math>); ↑DKAB Behavioural score (0.003); ↑Dietary stages of change score (<math>p = 0.007</math>); #HbA1c (%) (<math>p = 0.511</math>); #FBG (mmol/L) (<math>p = 0.345</math>)</p>
Zare et al., <sup>60</sup> Iran, 8 weeks of follow-up	$n = 120$ ; 43.7 years; CVD (hypertension)	Mobile app: access to education content including low-salt diet and reducing alcohol; 8 weeks; nutritionist; other lifestyle risk factor education	Usual care	<p>↑Self-care behaviour-Proper diet adherence (Hill-Bone questionnaire) (<math>p \leq 0.001</math>)</p>

(Continues)

TABLE 1 (Continued)

Study citation, location and follow-up	Participants	Intervention: detail; duration; HP involvement or guidelines use; and other aspects	Comparator	Results for dietary intake and clinical outcomes (between-group difference at longest follow-up time point)
<i>Hospital and community-based programmes</i>				
Boels et al., <sup>61</sup> Netherlands, <i>n</i> = 230; 58.6 years; DM 6 months of follow-up (type 2)		Mobile app with SMS: dietary 2–6× SMS/week, self-management education and support, challenges; push notifications; 6 months; dietitians, physiotherapists and nurse; SMS also related to PA and blood glucose control	Usual care	<p>#HbA1c (%) (<i>p</i> = 0.557); #BMI (<i>p</i> = 0.690); #SBP (mmHg) (<i>p</i> = 0.253); #DBP (mmHg) (<i>p</i> = 0.501); #TC (mmol/L) (<i>p</i> = 0.665); #HDL-C (mmol/L) (<i>p</i> = 0.393); #LDL (mmol/L) (<i>p</i> = 0.698); #TG (mmol/L) (<i>p</i> = 0.631); #SDSCA general diet (<i>p</i> = 0.845); #SDSCA high-fat foods (<i>p</i> = 0.312); #SDSCA fruit and vegetables (<i>p</i> = 0.553)#EQ-5D (<i>p</i> = 0.770); #ADDQoL (<i>p</i> = 0.891); #SF-36 physical component (<i>p</i> = 0.877); #SF-36 mental component (<i>p</i> = 0.702); #Healthy diet score (<i>p</i> = 0.881)</p>
Dorsch et al., <sup>62</sup> United States, 8 weeks of follow-up	<i>n</i> = 50; 57.4 years; CVD (hypertension)	Mobile app: push notifications to promote behaviour change when a participant entered a grocery store, restaurant, or home mobile app showed participant their selected alternatives to high-sodium food, provided a list of low-sodium meal options for restaurants, capability to search menus to scan universal grocery product codes; 8 weeks; researchers with health professional background	Usual care	<p>↓24-h urinary sodium excretion calculated from spot urine mg (<i>p</i> = 0.030); #Sodium intake measured by FFQ (mg/day) (<i>p</i> = 0.010); 24-h urinary sodium excretion (<i>p</i> = 0.470); #Sodium intake measured by 24-h dietary recall (mg/day) (<i>p</i> = 0.070); #SBP (mmHg) (<i>p</i> = 0.120)</p>
Vluggen et al., <sup>63</sup> Netherlands; 6 months of follow-up	<i>n</i> = 478; 60.1 years; DM (type 2)	Internet-based: Web-based text and video message feedback related to reducing calorie intake and unhealthy snacks; 6 months; nurses, dietitians and a GP; PA education	Usual care (wait-list control)	<p>↓Caloric intake from unhealthy snacks (<i>p</i> = 0.002)</p>

Abbreviations: ADDQoL, Audit of Diabetes Dependent Quality of Life; BCT, Behaviour Change Technique; BMI, Body Mass Index; cm, centimetres; CHO, Carbohydrate; CKD, Chronic Kidney Disease; CVD, Cardiovascular Disease; DASH, Dietary Approaches to Stop Hypertension; DBP, Diastolic Blood Pressure; DHD, Dutch Health Diet Index; DK AB, Dietary Knowledge Attitudes and Behaviour; DM, Diabetes Mellitus; DQI, Diet Quality Index; EQ-5D, EuroQoL Five Dimensions scale questionnaire; FBG, Full Blood Count; F2F, Face-to-face; FFBQ, Fat and Fibre Behaviour Questionnaire; FFQ, Food Frequency Questionnaire; g, grams; GP, General Practitioner; HbA1c, Haemoglobin A1c; HDL-C, High Density Lipoproteins Cholesterol; HP, health professional; kcal, kilocalories; kg, kilograms; kg/m<sup>2</sup>, kilograms per metre squared; LDL-C, Low Density Lipoproteins Cholesterol; MEDAS, Mediterranean Diet Adherence Score; mg, milligrams; mg/dL, milligrams per decilitre; milligrams per mercury; mmHg, millilitres; mmol/L, millimoles per litre; MUFA, Monounsaturated Fatty Acids; PA, Physical Activity; PUFA, Polyunsaturated Fatty Acids; QoL, Quality of Life; SBP, Systolic Blood Pressure; SDSCA, Summary of Diabetes Selfcare Activities Measure; SFA, Saturated Fatty Acids; SF, Short Form; SMS, Short Message Service; TC, Total Cholesterol; TG, Triglycerides; WC, Waist Circumference; WHO, World Health Organization.

<sup>a</sup>Criteria was participants with a BMI ≥ 30 kg/m<sup>2</sup> or BMI ≥ 28 kg/m<sup>2</sup> with a co-morbidity, however, overall mean = BMI > 30 kg/m<sup>2</sup>.

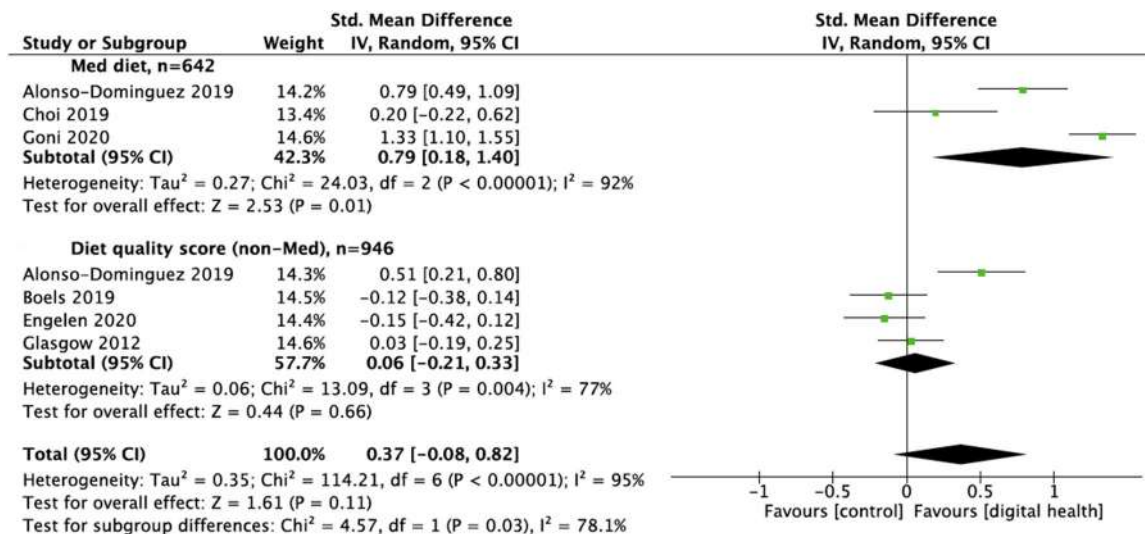


FIGURE 2 A forest plot displaying the effect of digital health on diet quality scores (Mediterranean diet adherence score and other diet quality scores) among adults with chronic conditions.

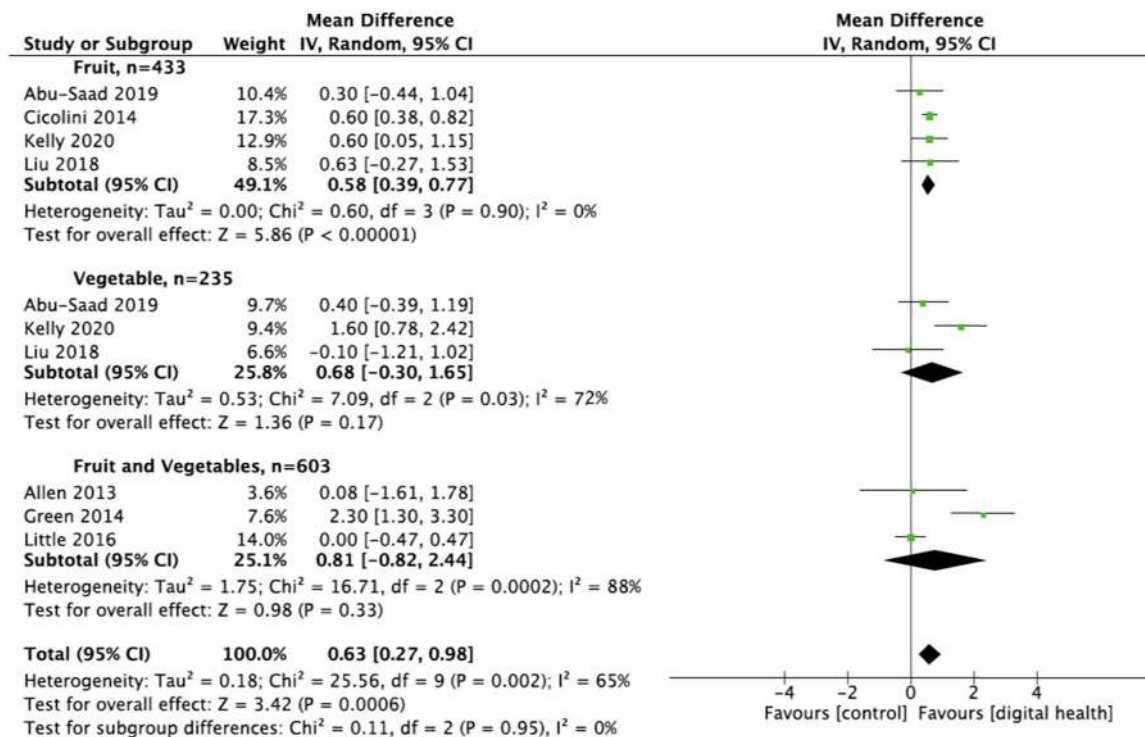


FIGURE 3 A forest plot displaying the effect of digital health on fruit and vegetable intake (fruit intake alone, vegetable intake alone and combined fruit and vegetable intake [servings/day]) among adults with chronic conditions.

effect (SMD = -0.18; 95% CI = -0.38 to 0.02;  $p = 0.08$ ;  $I^2 = 59\%$ ). Seven studies<sup>29,33-35,44,57,61</sup> included varying measures of fat intake (e.g., saturated fat and polyunsaturated fat intake) that could not be pooled. Forty-three percent of these studies reported significant changes in the digital health group compared to the control group (see Supporting information, Table S2).

## Fibre intake

Meta-analysis of four studies ( $n = 812$  participants)<sup>33,34,41,54</sup> found no effect of digital health interventions on fibre intake (MD = 2.56 grams/day; 95% CI = -0.13 to 5.24;  $p = 0.06$ ;  $I^2 = 66\%$ ). Two studies<sup>29,34</sup> included measures of fibre intake that could not

meta-analysed, with one showing significant improvements as a result of digital health compared to a control group (see Supporting information, Table S2).

## Protein intake

Five pooled studies ( $n = 927$  participants)<sup>28,33,34,41,54</sup> found no significant effect of digital health intervention on protein intake (MD =  $-0.13$  grams/day; 95% CI =  $-1.42$  to  $1.16$ ;  $p = 0.84$ ;  $I^2 = 12\%$ ). There were three studies<sup>34,35,44</sup> that reported varying measures of protein intake (e.g., protein component of diet quality index score and adherence to protein intake). One study found a significant improvements in protein intake as result of digital health intervention compared to the control (see Supporting information, Table S2).

## Other measures of dietary intake

Several other measures of dietary intake could not be meta-analysed due to varying measures and statistical reporting of intake (e.g., self-monitoring scores or other food groups). Varying results were reported across these studies (see Supporting information, Table S2).

## Methods of dietary assessment

Dietary intake assessment methods and modalities were heterogeneous across the included studies.

Sixty four percent of studies ( $n = 25$  studies)<sup>25–29,31–33,36,37,39,40,42,48,51–53,55–60,62,63</sup> used questionnaires (non-digital), and 15% ( $n = 6$  studies)<sup>28,36,38,41,44,47</sup> used interviews, 8% ( $n = 3$  studies)<sup>51,52,62</sup> used urinary testing and 5% used ( $n = 2$ )<sup>36,46</sup> diet records (non-digital) (see Supporting information, Table S3). Outcome assessment of dietary intake was undertaken via the internet in 15% of the studies ( $n = 6$  studies)<sup>30,34,50,61–63</sup> electronic software in 13% ( $n = 5$  studies)<sup>28,35,45–47</sup> one study<sup>49</sup> used mobile assessments and another used a combination of digital assessments (for a more detailed explanation of the technology, see Table 2). A similar proportion used technology for self-monitoring or compliance of dietary intake as part of the intervention: 17% ( $n = 7$  studies) used mobile assessment,<sup>26,27,42,46,49,55</sup> 7% ( $n = 3$  studies) used internet-based assessments<sup>31,32,50</sup> and one study used an electronic software<sup>45</sup> (Table 2). Some studies applied different methods for the outcome assessment and for self-monitoring or compliance. Of the three studies that utilised digital assessment tools to administer 24-h recalls or 3-day diet records,<sup>34,62</sup> one study<sup>34</sup> reported that they were checked for accuracy by a health professional. Only two studies<sup>42,46</sup> reported on the adherence of participants completing digital assessments. One found that participants recorded their dietary

intake an average of 53% of the time.<sup>46</sup> The other study indicated that input of a photo of a meal was higher than diet and exercise records via short messaging service; however, decreased to 51.2% by the end of the study.<sup>42</sup> No studies reported on the validity of digital assessment tools when compared to conventional methods.

## Digital health effect on clinical outcomes

### Anthropometric measurements

Digital health interventions significantly reduced body weight (MD =  $-1.94$  kilograms [kg]; 95% CI =  $-2.63$  to  $-1.24$ ;  $p < 0.00001$ ;  $I^2 = 32\%$ ) in nine pooled studies ( $n = 936$  participants)<sup>29,31,34,41,46,47,50,54,56</sup> and waist circumference (MD =  $-2.24$  cm; 95% CI =  $-4.14$  to  $-0.33$ ;  $p = 0.02$ ;  $I^2 = 78\%$ ) in nine pooled studies ( $n = 1149$  participants),<sup>26,34–36,41,46,47,54,56</sup> but had no significant effect on BMI ( $n = 1502$  participants)<sup>27,31,32,35,38,39,41,42,46,56,61</sup> (MD =  $-0.37$  kg/m<sup>2</sup>; 95% CI =  $-0.98$  to  $0.25$ ;  $p = 0.24$ ;  $I^2 = 42\%$ ) (Figure 4). Eight studies<sup>28,29,38,40,49,50,56,57</sup> reported on varying anthropometric measures (e.g., percentage weight loss and waist-to-hip-ratio) that could not be meta-analysed. Approximately 63% of those showed a significant positive change in the digital health group compared to the control (see Supporting information, Table S2).

### Blood pressure

Twenty-one studies reporting on SBP ( $n = 3395$  participants)<sup>26–29,31,35–37,39,41–43,47,48,50,51,53,54,57,61,62</sup> found no significant effect of digital health interventions (MD =  $-1.58$  millimetres of mercury [mmHg]; 95% CI =  $-3.65$  to  $0.49$ ;  $p = 0.14$ ;  $I^2 = 78\%$ ). Similarly, there was no significant effect of digital health on DBP (MD =  $0.03$  mmHg; 95% CI =  $-1.08$  to  $1.14$ ;  $p = 0.95$ ;  $I^2 = 68\%$ ) in a pooled analysis of 20 studies ( $n = 3227$  participants).<sup>26–29,31,35,36,39,41–43,47,48,50,51,53,54,57,61,62</sup> Both SBP and DBP results reported in one study<sup>40</sup> could not be pooled into the meta-analysis. This study similarly found no statistical difference between groups (see Supporting information, Table 2).

### Blood glucose control

Digital health interventions significantly reduced HbA1c in 13 studies involving 2,625 participants (MD =  $-0.17\%$ ; 95% CI =  $-0.29$  to  $-0.04$ ;  $p = 0.010$ ;  $I^2 = 26\%$ ).<sup>26–28,32,34,36,41,42,50,57–59,61</sup> There was no significant difference for FBG as a result of digital health (MD:  $-0.05$  millimoles per litre [mmol/L]; 95% CI =  $-0.25$  to  $0.15$ ;  $p = 0.62$ ;  $I^2 = 0\%$ ) in seven studies ( $n = 762$  participants).<sup>34,35,38,42,48,50,,59</sup> The participants included in these analyses had type 2 DM, obesity and or cardiovascular

TABLE 2 Assessment of dietary intake with use of digital tools

Author, year, country	Type of digital assessment tool	Name of digital assessment tool
Assessment of dietary intake as an outcome of the study		
Electronic software assessments		
Abu-Saad et al., <sup>45</sup> 2019, Israel	Questionnaire, embedded into nutrition software program	Interactive lifestyle Assessment, Counselling and Education (I-ACE) software
Allen et al., <sup>46</sup> 2013, United States	Nutrition software analysis program	Nutrition Data System for Research
Azar et al., <sup>47</sup> 2016, United States	Nutrition software analysis program <sup>a</sup>	Nutrition Data System for Research
Dawson et al., <sup>28</sup> 2021, Australia	Nutrition software analysis program	Xyris Software Foodworks
Lear et al., <sup>35</sup> 2014, Canada	Nutrition software analysis program	ESHA Food Processor SQL Software
Mobile assessments		
Donaldson et al., <sup>49</sup> 2014, United Kingdom	Diet record, based on proxy markers and sent via mobile SMS	N/A
Internet-based assessment		
Boels et al., <sup>61</sup> 2019, the Netherlands	Questionnaires, completed online	SDSCA; Kristal's FFQ
Dorsch et al., <sup>62</sup> 2020, United States	24 h diet recall, completed online	Self-administered 24-h dietary (ASA24) assessment tool
Duan et al., <sup>30</sup> 2018, Hong Kong	Questionnaire, completed online	Behaviour risk factor surveillance system
Green et al., <sup>50</sup> 2014, United States	Questionnaire, completed online	N/A
Hansel et al., <sup>34</sup> 2017, France	Diet record and questionnaire, completed online <sup>a</sup>	3-day food record and DQI
Vluggen et al., <sup>63</sup> 2021, the Netherlands	Nutrition online database	Dutch Nutrition Center calorie database
Combined assessment		
Kelly et al., <sup>54</sup> 2020, Australia	Questionnaire, completed online and Nutrition analysis software	Australian Eating Survey; FoodWorks
Assessing dietary intake for self-monitoring or compliance as part of the intervention		
Electronic software assessment		
Abu-Saad et al., <sup>45</sup> 2019, Israel	Questionnaire, embedded into nutrition software program	Interactive lifestyle Assessment, Counselling and Education (I-ACE) software
Mobile dietary assessment		
Allen et al., <sup>46</sup> 2013, United States	Diet record, embedded into mobile app <sup>a</sup>	Lose it mobile application
Alonso-Dominguez et al., <sup>26</sup> 2019, Spain	Diet record, embedded into mobile app	Evident II mobile application
Choi et al., <sup>27</sup> 2019, United States	Diet record, embedded into mobile app	Vibrent mobile application
Donaldson et al., <sup>49</sup> 2014 United Kingdom	Diet record, based on proxy markers and sent via mobile SMS	N/A
Goni et al., <sup>33</sup> 2020, Spain	Questionnaire, embedded into mobile app	Mediterranean diet adherence score via Predimar app
Ku et al., <sup>55</sup> 2019, Korea	Diet record, embedded in mobile app	Noom Coach mobile app
Waki et al., <sup>43</sup> 2014, Japan	Diet record, via SMS	N/A
Internet-based dietary assessment		
Engelen et al., <sup>31</sup> 2020, the Netherlands	Diet record, embedded into website	Vascular view web-based programme
Glasgow et al., <sup>32</sup> 2012, United States	Diet record, embedded into website	My path to health life website
Green et al., <sup>50</sup> 2014, United States	Diet record shared, via electronic health record-linked secure messaging system	N/A

Note: Electronic software assessment: nutrition analysis software programs that did not specify internet use; Internet based assessment: websites, emails and nutrition database; Mobile assessment: SMS or apps.

Abbreviations: FFQ, Food Frequency Questionnaire; DQI, Diet Quality Index; N/A, not applicable; SDSCA, summary of diabetes selfcare measure; SMS, short message service.

<sup>a</sup>Health professionals checked accuracy of diet with participant; x: did not specify; ✓: did specify.



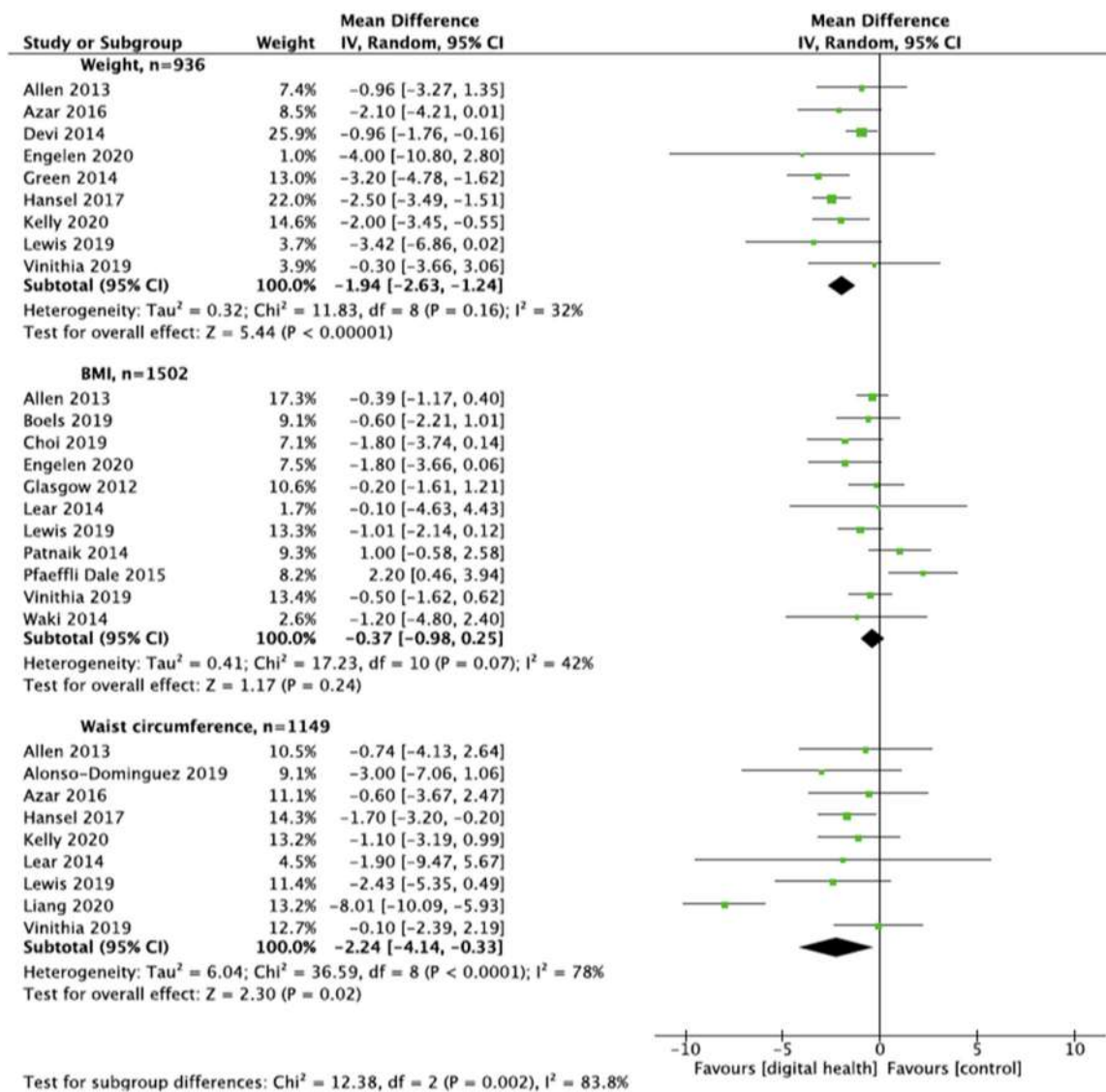


FIGURE 4 A forest plot displaying the effect of digital health for body weight (kg), body mass index ( $\text{kg}/\text{m}^2$ ) and waist circumference (cm) among adults with chronic conditions.

disease. Four studies<sup>26,38,55,61</sup> reported on other measures of blood glucose (e.g., summary of diabetes self-care measure blood sugar testing component and post prandial blood glucose) that could not be included in the meta-analysis (see Supporting information, Table S2); all reporting no significant difference between groups.

### Blood lipids

Digital health interventions had no significant effect on TC, HDL-C, LDL-C and triglycerides. However, HDL-C results were significant for 10 trials that used a single mode of digital health delivery (MD = 0.04 mmol/L; 95% CI = 0.00 to 0.08;  $p = 0.03$ ;  $I^2 = 68\%$ ) ( $n = 1,560$  participants).<sup>26,27,31,34,35,41,42,47,50,57</sup> One study that reported on all blood lipid outcomes<sup>40</sup> could not be

included in the analysis because of variations in reporting of statistical data. No statistical difference between groups was found for this study (see Supporting information, Table S2).

### Quality of life and self-efficacy

Seven studies reporting on QoL (9 comparisons,  $n = 1,927$  participants)<sup>29,32,41,51,53,57,61</sup> found no significant difference between the digital health intervention and control (SMD = 0.01; 95% CI = -0.08 to 0.10;  $p = 0.76$ ;  $I^2 = 0\%$ ). Four studies reported on self-efficacy for diet ( $n = 710$  participants)<sup>29,31,32,39</sup> and showed no statistical change as a result of the digital health intervention (SMD = 0.11; 95% CI = -0.04 to 0.26;  $p = 0.16$ ;  $I^2 = 0\%$ ). A further six studies that reported on QoL

measures<sup>28,30,47,49,50,61</sup> could not be meta-analysed because of variation in reporting data and only one showed a significant effect between groups for QoL as result of digital health (see Supporting information, Table S2).

## Hospitalisation and mortality

The one study (78 participants and 16 months of follow-up)<sup>35</sup> that reported on hospitalisation and mortality found no significant benefit of digital health compared to control (see Supporting information, Table S2).

## Quality assessment

Seventy-nine percent of the studies demonstrated a high risk of bias for measurement of outcome, mainly because the outcome measure of primary focus for this review (dietary intake) was self-reported by participants (see Supporting information, Figure S1). The allocation sequence was random and concealed for 40% of the studies and blinding was adequately reported in 50% of the studies. More than 75% of the studies had evidence that missing outcome data was a minimal risk of bias and 42% sufficiently reported on the selection of the reported result. The majority of studies were classified predominantly low to moderate quality after applying the GRADE framework to the body of evidence (see Supporting information, Table S4).

## DISCUSSION

This systematic review evaluated the effectiveness of dietary interventions delivered by digital health for improving dietary intake in people with chronic conditions. The study revealed that mobile and electronic health interventions can generally produce small to moderate positive changes in the Mediterranean diet score (a diet quality score), fruit and vegetable intake, sodium, body weight, waist circumference and HbA1c. Statistically significant effects were not found for other measures of dietary intake and certain clinical markers of nutrition; however, promising trends toward digital health were still found for some of these outcomes.

Dietary education via digital health can translate into small improvements in dietary intake. A significant increase to the Mediterranean diet adherence score was found, equating to a back transformed MD of 1.3 points. A 2-point increment in a Mediterranean diet adherence score has improved all-cause mortality in adults with a history of cardiovascular disease.<sup>64</sup> However, a smaller increment of 1 point in the Mediterranean diet score, comparable to our study, reduced the risk of cardiovascular events for those with history of coronary heart

disease<sup>65</sup> or at risk of CKD.<sup>66</sup> Although this evidence suggests that digital health can support people with chronic conditions to better align their diet with the Mediterranean pattern of eating, whether this translates to improved cardiovascular protection remains unclear. Furthermore, overall fruit and vegetable intake increased by slightly over half a serving per day. Other reviews have shown varying statistical significance of fruit and vegetables as a combined measure.<sup>12,13,16</sup> Adequate fruit and vegetable intake have been associated with reduced cardiovascular<sup>67,68</sup> and cancer risk as well as all-cause mortality.<sup>67</sup> There is low intake of fruit and vegetable intake globally,<sup>69</sup> with small improvements possibly relevant from a public health perspective. Other telehealth modalities (broader than mHealth and eHealth alone) have shown improved diet quality scores and fruit and vegetable intake.<sup>13,17</sup> However, similar to our review, a small number of studies reported these outcomes and therefore there is still a need for additional trials to determine the effect of digital health on these dietary intake measures.

The methods used to assess dietary intake within the included studies varied. Studies reported using more conventional assessments (i.e., paper-based questionnaires or recall methods) rather than the involvement of digital assessment methods to measure dietary intake as an outcome. Mobile and electronic dietary assessments may have features designed to improve the ease of use and accuracy of more conventional methods<sup>9</sup> including barcode scanning, direct data entry or image-based diet capture.<sup>70</sup> Despite these benefits, validation studies of mobile dietary assessments have revealed under-reporting of nutrients and food groups compared to objective or conventional methods.<sup>71</sup> Knowing whether these tools are valid will likely influence their use within research and clinical practice settings. Therefore, more validation studies and better reporting on the validity of digital assessment tools used in research are needed to ensure confidence in findings.

The random effects meta-analysis showed a significant reduction in weight and waist circumference with digital health intervention. Other reviews of digital health have reported similar findings for weight<sup>16,17</sup> and waist circumference.<sup>13,16,17</sup> Digital health offers the opportunity for health professionals to monitor progress by receiving health data for the patient which is important considering frequent follow-up is recommended for weight management.<sup>72,73</sup> Furthermore, digital health intervention aimed at supporting weight loss and maintenance often targets multiple psychological constructs and behavioural strategies.<sup>74</sup> Exemplifying this, a meta-analysis found greater weight loss in mobile-based interventions compared to the controls, especially when it also involved a tracker (weighing scales, step and bite counters) and behavioural coaching or feedback.<sup>75</sup> Whether the studies meta-analysed for weight and waist circumference in our review involved behavioural

techniques or activity tracking needs to be investigated further. Or review does highlight the potential benefit of multi-component interventions with varying technology features and behavioural strategies to assist with weight management.

A number of dietary and clinical outcomes had clinically modest improvements or no effect. There are many potential reasons for this, which warrant further comment. For example, outcomes in mHealth research can be substantially influenced by the perceived user appropriateness, as well as its tailoring to patients' conditions, lifestyles and cultures.<sup>76</sup> Research has identified that digital health interventions involving counselling and tailored feedback improve dietary behaviour among a general population.<sup>77</sup> In addition, a Dietetic Position Statement suggests that digital health interventions may be useful in supporting nutrition delivery<sup>78</sup>; however, there appears to be insufficient evidence to suggest their clinical usefulness as a standalone intervention. Future research studies in this area are needed.

### Strengths and limitations

This systematic review is strengthened by the use of the PRISMA guidelines, a comprehensive search strategy across four databases, and the use of two independent investigators performing duplicate screening and risk of bias assessment. In addition, several study authors were contacted to obtain additional information to inform eligibility assessment. There are also limitations worth noting. First, the inclusion of non-randomised trials means that there is potential for confounding, selection and information bias among these studies.<sup>79</sup> Furthermore, most studies had a duration  $\leq 12$  months (79%) and therefore, findings may only be applicable to short term intervention durations. We also acknowledge that the appraisal of articles using Google translator is prone to error in comparison with English language articles. A further limitation is the standardisation of several measures that could have introduced measurement error in the analysis. In addition, findings for clinical outcomes were not necessarily an effect of diet alone because the interventions were diverse, with some including face-to-face or other lifestyle components. We classified assessment tools completed online as digital assessment methods; however, we may not have identified all that were completed online because it is possible that the administration of the assessment was not detailed in the method of the studies. In addition, the studies did not always clearly articulate dietary education and whether it provided the knowledge and skills on how to change a dietary behaviour, which is considered as the core aspect of nutritional education.<sup>80</sup> This highlights the need for better reporting of dietary education in these digital health interventions. The quality of evidence was rated mostly

low to moderate according to the GRADE framework, with the consideration that the studies were predominantly low or unclear across each of the risk of bias domains.

### CONCLUSIONS

In conclusion, we have summarised the literature on dietary education delivered by digital health interventions and found improvements in diet quality scores, fruits and vegetable intake, sodium intake, body weight, waist circumference and HbA1c measures. However, because there were only modest or non-significant results for a number of reported outcomes of interest, there is limited evidence supporting the effectiveness of eHealth and mHealth for diet and clinical outcomes. Therefore, there is a need to further understand the specific components of digital health that might influence its effectiveness and allow it to be a standalone model of care. There is also need for better reporting on dietary assessment measures including the validity of digital assessment methods and content of education in dietary intervention studies. Furthermore, future studies need to clearly outline knowledge and skills that can be obtained from the dietary education component of the intervention. Overall, the review highlights the need to conduct more robust trials to guide the implementation and scale up of digital health interventions in health services.

### AUTHOR CONTRIBUTIONS

Amandine Barnett, Hannah L. Mayr, Jaimon T. Kelly, Nok Yin Ho, Pooja Adhyaru and Sarah Kostjasyn contributed to study design. Amandine Barnett, Charlene Wright and Christine Stone contributed to screening. Amandine Barnett, Charlene Wright and Christine Stone contributed to data extraction. Amandine Barnett, Charlene Wright and Jaimon T. Kelly contributed to statistical analysis. Amandine Barnett led the initial draft of the manuscript. Amandine Barnett, Charlene Wright, Christine Stone, Ingrid J. Hickman, Katrina L. Campbell, Hannah L. Mayr and Jaimon T. Kelly contributed to the reviewing and editing of the manuscript. All authors read and approved the final version of the manuscript submitted for publication.

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## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. The reporting of this work is compliant with PRISMA guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned (PROSPERO:CRD42021269363) have been explained.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# The impact of living through COVID-19 pandemic on mental health, food insecurity, loneliness and health behaviours in people with obesity

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## Abstract

**Background:** The COVID-19 pandemic has negatively impacted people living with obesity. The aim was to examine the continued impact of the COVID-19 pandemic on the mental health of people living with obesity and associations with food insecurity, loneliness and health-related behaviours.

**Methods:** The study recruited 1187 UK adults living with obesity who completed an online survey, which examined mental health and associations with food insecurity, loneliness and health-related behaviours from July 2020 (end of the first lockdown in the United Kingdom) to the point they completed the survey in 2021. Regression analyses were used to examine relationships between outcome variables and demographic factors, and hierarchical linear regression models were used to assess levels of loneliness, depression and well-being.

**Results:** Participants reported worse loneliness, depression, well-being and food insecurity compared to pre-COVID. However, participants reported attempting to lose weight, healthier food shopping, diet and increased physical activity. Quality and quantity of sleep deteriorated compared to prior to COVID-19.

**Conclusions:** Adults living with obesity in the United Kingdom report a continued negative impact of the COVID-19 pandemic upon their mental health together with increased loneliness and food insecurity. However, our findings suggest that UK adults living with obesity have increased their engagement in positive health behaviours and were attempting to lose weight.

## KEYWORDS

COVID-19, food insecurity, loneliness, mental health, obesity

## Key points

- People living with obesity are actively attempting to improve their health-related behaviours since the first COVID-19 lockdown.
- Better mental health was associated with healthier food shopping and diet, increased physical activity and better sleep.
- Food insecurity and loneliness were higher among people living with obesity than previously reported in the general population.
- The findings have implications for policymakers and healthcare professionals regarding the importance of continuing mental health support and addressing food insecurity and loneliness, both now and as the pandemic evolves.

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## INTRODUCTION

Substantive evidence has shown the negative impact of coronavirus disease 2019 (COVID-19) on people living with obesity.<sup>1,2</sup> Although earlier research focused on the increased risk of severe COVID-19, attention soon shifted to mental health, with a systematic review reporting the unprecedented impact on mental health in the general population,<sup>3</sup> with similar outcomes reported in people living with obesity.<sup>1</sup> National restrictions, including social distancing and shielding, have impacted on the way people live, leading to a focus on loneliness<sup>4</sup> and the long-term negative impact on health behaviours.<sup>1</sup> Due to greater restrictions imposed on them, people identified as ‘high risk’ were disproportionately impacted.<sup>5</sup>

Prior to COVID-19, food insecurity, including foodbank usage, was increasing, with about 2.5% of all UK households using foodbanks in 2019–2020<sup>6</sup> and 10% of UK adults reporting low or very low food security.<sup>7</sup> During COVID-19 these figures increased, with the lack of access to food in supermarkets and isolation reported as factors to explain low or very low food security.<sup>8</sup> Furthermore, furloughing and unemployment have also resulted in greater food insecurity and foodbank usage during the pandemic,<sup>9</sup> with further concerns now reported as a result of the ‘cost of living crisis’ in the United Kingdom,<sup>10</sup> although data specifically relating to people living with obesity remain sparse. Therefore, we aimed to examine the continued impact of COVID-19 on the mental health of people living with obesity and associations with food insecurity, loneliness and health-related behaviours.

## METHODS

Between 20 April and 6 September 2021, 1187 UK adults living with obesity completed an online survey hosted by UCL Opinio. Eligibility criteria were people living with obesity (BMI  $\geq 30$  kg/m<sup>2</sup>) and aged 16–80 years.

Participants were recruited using Prolific, a participant pooling tool, alongside invitations disseminated via social media; professional and patient obesity organisations; and obesity services, including the Association for the Study of Obesity, the British Dietetic Association and the British Obesity and Metabolic Surgery Society (see Supporting Information for the full list). We used multiple recruitment methods to allow for snowball sampling and to increase the diversity of people living with obesity participating in the study. The Prolific participant pooling mechanism helped to ensure that we recruited sufficient and balanced numbers of participants in terms of demographic factors, including ethnicity, gender and place of residence. Prior to completing the survey, the participants were provided with an online information sheet, and they provided electronic informed consent. The participants were asked about their experiences from July 2020 (end of the first lockdown in

the United Kingdom) to the point they completed the survey in 2021. The participants were asked to complete a series of questions regarding the continued impact of COVID-19 since the first national lockdown in the United Kingdom. Subsections of the survey were as follows:

1. Demographics
2. Awareness, thoughts and actions relating to COVID-19
3. Service provision
4. Impact on mental health, food insecurity and health behaviours
5. Discrimination and stigma

Validated questionnaires to assess food security, loneliness, well-being and depression were included. These questionnaires were chosen to correspond with our previous study,<sup>1</sup> allowing for comparisons of outcome data.

### USDA Adult Food Security Questionnaire

Food security was assessed using the USDA adult food security questionnaire.<sup>11</sup> Participants were asked 10 questions relating to food security in the past 30 days. The questionnaire has a three-item response scale: (1) ‘don’t know’, (2) 0 = ‘only 1 or 2 days’ or (3) 1 = ‘almost every day’. Scores were summed and categorised into a three-level score (0 = high, 1–2 = marginal and 3–10 = low/very low food security) and used as both an ordinal outcome variable and a categorical explanatory variable.

### Three-item UCLA Loneliness Scale

Participants completed the three-item UCLA Loneliness Scale,<sup>12</sup> involving three negatively worded questions that measure three dimensions of loneliness: relational connectedness, social connectedness and self-perceived isolation. A total score from 3 to 9 was computed by adding up the response to each question: 1 = ‘hardly ever’, 2 = ‘some of the time’ or 3 = ‘often’. Loneliness was used as a continuous outcome variable and as a binary explanatory variable (3–5 = no vs. 6–9 = yes).

### Warwick–Edinburgh Mental Well-Being Scale

Participants completed the 14-item Warwick–Edinburgh Mental Well-Being Scale (WEMWBS)<sup>13</sup> to measure mental well-being. They were asked to tick the box that best describes each of their experiences over the past 2 weeks. This comprised 14 positively worded statements, with 5 response categories from ‘1’ (none of the time) to ‘5’ (all the time). The answers were then added up to give

a total score. This was then compared with the population centiles from the UK population<sup>14</sup> (top 15th centile: WEMWBS score 60–70; bottom 15th centile: WEMWBS score 14–42) and the remainder (16th–84th percentile: WEMWBS score 43–59). WEMWBS was used as a continuous outcome and an explanatory variable.

## Patient Health Questionnaire-9

The nine-item Patient Health Questionnaire (PHQ-9)<sup>15</sup> was used to assess depression. Participants are asked over the past 2 weeks how often they have been bothered by any of the nine DSM-IV (*Diagnostic and Statistical Manual of Mental Disorders*, fourth edition) criteria from '0' (not at all) to '3' (nearly every day); these were then added up to give a total score. This was compared with the interpretation box to indicate depression severity from minimal depression to severe depression. PHQ-9 was used as a continuous outcome variable and an explanatory variable.

## Assessment of changes in shopping, diet, physical activity, sleep and alcohol intake

Each participant was asked two questions about his or her health behaviours since the end of the first lockdown in July 2020. Participants were first asked whether the health behaviour had changed, being able to respond: 'not at all', 'a little', 'a moderate amount', 'a lot' or 'a great deal' (for sleep, participants could respond 'yes' or 'no'). Participants were then asked about the direction of change, being able to respond: 'worsened/unhealthier/decreased', 'no change' or 'better/improved/increased'. Changes (in magnitude or direction) in shopping/diet/physical activity/sleep/alcohol intake were used as ordinal outcome variables.

This survey was developed to explore the continued impact of the COVID-19 pandemic on people living with obesity. The survey was developed in collaboration with people living with obesity recruited from obesity advocacy groups and patients. This ensured that the length, terminology and questions were relevant and understood by people living with obesity. The study was granted ethical approval by the UCL Research Ethics Committee (REC number: 16191/004).

## Data analysis

Normally distributed variables were assessed using means and standard deviations, whereas medians and interquartile ranges were used for nonparametric variables. Categorical variables were assessed using counts (percentages) and compared using  $\chi^2$  tests. Statistical analyses were performed using SPSS (version 27.0).

Statistical significance was defined as  $p < 0.05$ . Data quality was assessed prior to analysis.

Due to insufficient numbers in other categories (transgender and other), only participants reporting 'male' or 'female' gender were included in the regression analyses. Ethnicity was not included as an explanatory variable due to insufficient numbers in the ethnic categories other than 'White ethnicity'.

Ordinal outcome variables (health behaviours and food security) were assessed using ordinal logistic regression. Three models were constructed for each outcome variable, with the following explanatory variables: (1) age (continuous), gender (male vs. female), BMI (continuous), number of additional risk factors for COVID-19 (categorical: 0, 1 or 2+) and food security (categorical: very low/low, marginal or high food security); (2) model 1 + loneliness (categorical, yes vs. no); and (3) model 2 + well-being (continuous WEMWBS) and depression (continuous PHQ-9). For food security, models 2 and 3 were assessed. For change in sleep (yes vs. no), a binary regression model was used, with the same explanatory variables.

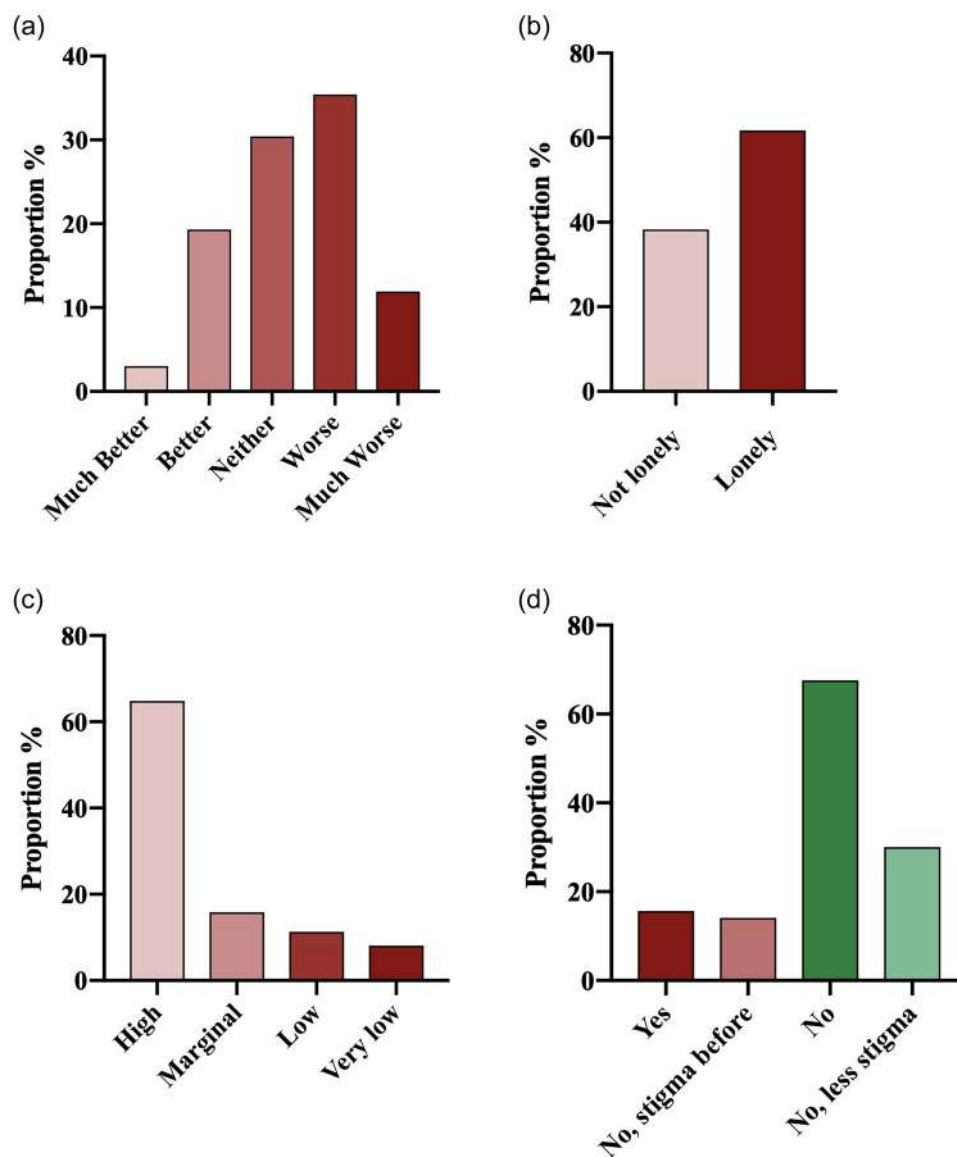
Stigma (yes ['yes', 'no, I felt stigmatised during the first lockdown and before the COVID-19 outbreak'] vs. no ['no', 'no, I feel less discriminated against compared to the end of the first lockdown in July 2020']) was assessed using a binary regression model with the following explanatory variables: (1) age (continuous), gender (male vs. female), BMI (categorical [continuous variable violated assumption linearity]:  $<40$  vs.  $\geq 40$  kg/m<sup>2</sup>), well-being (continuous WEMWBS) and depression (continuous PHQ-9).

Continuous outcome variables (loneliness, depression and well-being) were assessed using hierarchical linear regression models. Four models were constructed for each outcome variable, with the following explanatory variables: (1) age (continuous), gender (male vs. female), BMI (continuous) and number of additional risk factors for COVID-19 (categorical: 0, 1 or 2+); (2) model 1 + perceived stigma (yes vs. no), self-reported mental health since the end of the first lockdown (categorical: much worse, worse, neither, better or much better); (3) model 2 + food security (categorical: very low/low, marginal or high food security) + loneliness (categorical: yes vs. no); and (4) model 3 + well-being (continuous WEMWBS) and depression (continuous PHQ-9). The assumptions of each model were checked and met.

## RESULTS

Participants had a mean age of 38.3 years (standard deviation [SD]: 12.0); 734 (61.8%) were female, with a median BMI of 36.2 kg/m<sup>2</sup> (interquartile range [IQR]: 33.1–41.2); 935 (78.8%) identified as White British, Irish or other ethnicity; 828 (69.8%) lived in England; and 464 (39.1%)  $\geq 1$  additional risk factors related to severe illness from COVID-19 (Supporting Information, Table S1).





**FIGURE 1** Reported changes in mental health, stigma and loneliness since the end of the first COVID-19 lockdown in people living with obesity. (a) Changes in mental health since the end of the first COVID-19 lockdown. (b) Loneliness, assessed using the three-item UCLA Loneliness Scale. (c) Food security, assessed using the USDA adult food security survey. (d) Reported experiences of weight stigma since the end of the first COVID-19 lockdown.

Nearly half of the participants (47.3%, 561) reported their mental health had become worse or much worse since the first COVID-19 lockdown (Figure 1a). Mean depression score (PHQ-9) was 11.3 (SD: 6.8), with 32.4% (384) reporting moderately severe to severe depression (Supporting Information, Figure S1A). Mean well-being score (WEMWBS) was 40.7 (SD: 10.5), with 58.5% (694) reporting low well-being (Supporting Information, Figure S1B; Table S2). Nearly one-third (32.6%, 387) reported seeking medical support for their mental health since July 2020. Higher BMI, having two or more risk factors, reporting much worse mental health and being lonely were associated with higher depression, whereas higher well-being, high food security and old age were associated with lower depression (model 4, Supporting

Information, Table S3). Greater loneliness, worse mental health and higher depression were associated with lower well-being (model 4, Supporting Information, Table S3).

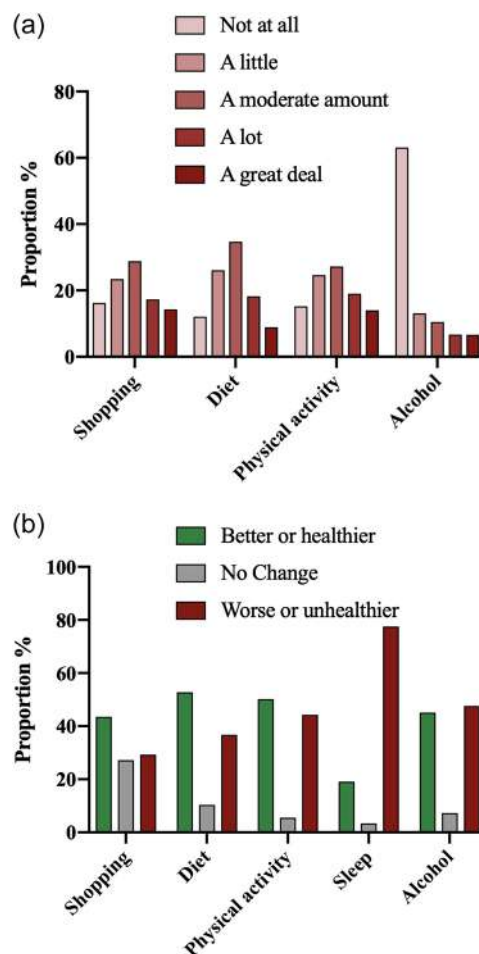
A total of 732 (61.7%) participants reported feeling lonely, with a mean loneliness score of 6.0 (SD: 2.0); 27.4% (325) reported high loneliness, which was greater than that reported in the general population (Figure 1b; Supporting Information, Table S2).<sup>16</sup> Greater loneliness was associated with experiencing weight stigma, lower food security, lower well-being and higher depression (model 4, Supporting Information, Table S3).

Very low food security was reported by 96 (8.1%) participants, 2.7 times greater than that reported by Pool and Dooris<sup>17</sup> in a sample of UK adults in 2019 (Figure 1c). Overall, 160 (13.5%) participants reported

eating less than they should, 125 (10.5%) were hungry but did not eat and 46 (3.9%) did not eat for a whole day due to insufficient money or food. This indicates greater food insecurity in our sample compared with the UK general population.<sup>18</sup> Further analysis showed those experiencing very low and low food security were more likely to be lonely and have higher depression (odds ratio [OR]: 1.49, 95% confidence interval [CI]: 1.11–2.01,  $p = 0.009$ ; OR: 1.06, 95% CI: 1.03–1.09,  $p < 0.001$ ) (Supporting Information, Table S4), whereas older participants and those with no additional risk factors were less likely to report food insecurity (OR: 0.96 per additional year in age, 95% CI: 0.95–0.97,  $p < 0.001$ ; OR: 0.62, 95% CI: 0.40–0.96,  $p = 0.031$ ) (Supporting Information, Table S4), in agreement with Pool and Dooris.<sup>17</sup>

Since July 2020, 183 (15.6%) reported experiencing more weight stigma, 793 (67.6%) did not feel stigmatised, 165 (14.1%) felt stigma had not changed due to feeling stigmatised before July 2020 and 32 (2.7%) felt less stigmatised (Figure 1d). Those reporting feeling stigmatised were more likely to be female and have a higher BMI and higher depression (OR: 2.24, 95% CI: 1.65–3.04,  $p < 0.001$ ; 2.86 per additional BMI point, 95% CI: 2.15–3.80,  $p < 0.001$ ; 1.06 per additional point in depression, 95% CI: 1.03–1.09,  $p < 0.001$ ), whereas those with higher well-being were less likely to report feeling stigmatised (OR: 0.97 per additional point in well-being, 95% CI: 0.95–0.99,  $p = 0.006$ ) (Supporting Information, Table S5).

Most participants reported a change in health-related behaviours (Figure 2a), with the majority reporting healthier or positive changes, with 945 (79.6%) reporting actively attempting to lose weight (Supporting Information, Table S6). Food shopping behaviour became healthier for 432 (43.5%) participants, and over half reported a healthier diet or greater physical activity (550, 52.8%; 503, 50.2%, respectively) (Figure 2b). Alcohol intake did not change in 744 (63.1%) (Figure 2a), and of those who did report a change, 197 (45.1%) reported a lower intake (Figure 2b). However, 796 (67.2%) reported using food to manage their emotions. Sleep was negatively impacted (587, 49.7%), with 454 (77.5%) reporting that their sleep worsened (Figure 2b). Compared with those with very low and low food security, participants with high food security were more likely to report their food shopping and diet becoming healthier (*shopping*: OR: 1.60, 95% CI: 1.17–2.18,  $p = 0.003$ ; *diet*: OR: 1.40, 95% CI: 1.03–1.92,  $p = 0.035$ , respectively) (model 1, Supporting Information, Table S7). In addition, those with high food security had a higher likelihood of increased physical activity and better sleep (OR: 1.53, 95% CI: 1.10–2.12,  $p = 0.011$ ; OR: 1.92, 95% CI: 1.14–3.24,  $p = 0.015$ , respectively). When adding loneliness as a predictor, higher food security continued to predict healthier food shopping and increased physical activity (model 2, Supporting Information, Table S7). However, when well-being and depression were added, food insecurity no



**FIGURE 2** Reported changes in health-related behaviours in people living with obesity. (a) Magnitude of change in health-related behaviours since the end of the first COVID-19 lockdown. (b) Direction of change in health-related behaviours since the end of the first COVID-19 lockdown

longer predicted a change in health-related behaviour (model 3, Supporting Information, Table S7). When looking at loneliness, participants who reported being lonely had a lower likelihood of healthier food shopping and diet, increased physical activity and better sleep compared with those who reported not being lonely (OR: 0.52, 95% CI: 0.41–0.67,  $p < 0.001$ ; OR: 0.57, 95% CI: 0.44–0.74,  $p < 0.001$ ; OR: 0.64, 95% CI: 0.50–0.83,  $p = 0.001$ ; OR: 0.46, 95% CI: 0.31–0.70,  $p < 0.001$ , respectively). Again, when well-being and depression were added to the models, loneliness no longer predicted a change in health-related behaviour (Supporting Information, Table S7).

## DISCUSSION

This study shows the COVID-19 pandemic has continued to impact negatively on the mental health of people living with obesity, alongside higher levels of loneliness

and food insecurity compared with the general population.<sup>16</sup>

Unlike previous studies reporting that among people living with obesity, health-related behaviours have become worse and weight had increased,<sup>1,19</sup> these data show the opposite. A greater percentage of people living with obesity are actively attempting to lose weight compared with prior to the COVID-19 pandemic,<sup>20</sup> and during the first lockdown,<sup>1</sup> healthy behaviours have increased. Most participants reported healthier food shopping, diet and increased physical activity, although alcohol intake did not change as much, and sleep continued to worsen. Further research exploring the reasons for these changes is needed; these might reflect the wide-scale messaging regarding the increased risk of severe illness in people living with obesity from COVID-19<sup>2</sup> and greater national focus, such as the UK government's 2020 Obesity Strategy.

Food insecurity and loneliness were substantially higher than that previously reported in the general populations both before and during the first COVID-19 lockdown and later.<sup>16,17</sup> Research reported that financial vulnerability during COVID-19 explained between 5% and 25% of reporting food insecurity.<sup>8,21</sup> Therefore, the impending 'cost of living crisis' has the potential to further increase health inequalities and negatively impact food availability, access and choice.<sup>22</sup> The relationship between obesity (and indeed other long-term health conditions, e.g., type 2 diabetes, depression) and level of deprivation, indicates higher prevalence of obesity in more deprived communities.<sup>23</sup> This suggests that the government's decision to scale back the UK government's 2020 Obesity Strategy may mean that the impact of COVID-19, 'cost of living crisis' and reduced government intervention is likely to have a long-term impact on the health of the nation, and greater impact on people in the most vulnerable category.

Our study is limited by its cross-sectional nature. However, in agreement with our findings, a longitudinal study by Chao and colleagues<sup>24</sup> in older adults living with overweight or obesity and type 2 diabetes showed that worse depression and loneliness increased during the COVID-19 pandemic compared to before the pandemic. Both food insecurity and loneliness being predictors of worse depression and well-being highlights their importance on mental health. Moreover, previous studies have shown that loneliness and isolation are associated with increased risk of various health conditions and all-cause mortality.<sup>25,26</sup> Therefore, policymakers need to address strategies to reduce people experiencing food insecurity and loneliness, particularly if restrictions continue or there are ongoing economic impacts of the pandemic and the 'cost of living crisis'.

Better mental health (higher well-being and lower depression) appeared to be the main driver of both likelihood of reporting healthier and less change in health-related behaviours. Our data suggest that mental

health has continued to be disproportionately impacted in people living with obesity compared with data from the general population<sup>16</sup> and during the first lockdown.<sup>1</sup>

Encouragingly, the current study findings show that people living with obesity are seeking medical support for their mental health. Although the number is only one-third, this is higher than reports from the general population.<sup>27</sup> However, this might represent a greater number of people with a pre-existing mental health condition in our cohort but also that the pandemic continues to disproportionately impact the mental health of people living with obesity.

Our findings need to be interpreted after considering the following limitations. As previously mentioned, these data are cross-sectional, and online recruitment may have limited the response from those with digital poverty. In addition, as participants were surveyed about over a 5-month period of easing restrictions and also asked to recall on their experiences from the first lockdown, this may have influenced responses and been prone to recall bias. However, as the majority (95%) replied during August, this is unlikely to have had an impact.

## CONCLUSION

The findings of this study have implications for policy-makers and healthcare professionals who are involved with supporting people living with obesity, notably the continued impact on mental health, and need to address food insecurity and loneliness, both now and as the pandemic evolves.

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### AUTHOR CONTRIBUTIONS

Adrian Brown conceived the study. Adrian Brown, Stuart W. Flint, Rachel L. Batterham, Simon Williams, Mary O'Kane and Anastasia Z. Kalea contributed to the study and survey design and methodology. Adrian Brown was responsible for the oversight of the study. Adrian Brown, Stuart W. Flint, Rachel L. Batterham, Simon Williams, Mary O'Kane, Erika Wong and Anastasia Z. Kalea contributed to the recruitment of participants. Samuel J. Dicken, Adrian Brown, Stuart W. Flint and Rachel L. Batterham were responsible for data analysis. Adrian Brown, Stuart W. Flint, Rachel L. Batterham and Samuel J. Dicken contributed to initial data interpretation and the writing of the first draft. All authors contributed to critical revision of the manuscript and gave final approval.

### CONFLICT OF INTEREST

Adrian Brown reports support grant from Novo Nordisk in relation to this submitted work and honoraria from Novo Nordisk, PHE and Obesity UK outside the submitted work; Adrian Brown is on the medical advisory board and a shareholder of Reset Health Clinics Ltd. Rachel L. Batterham reports personal fees from Novo Nordisk; others from Novo Nordisk; and personal fees from Pfizer, International Medical Press, Boehringer Ingelheim, and ViiV outside the submitted work. Stuart W. Flint reports research grants and support for attendance at academic meetings from Johnson & Johnson and Novo Nordisk, research grants from Public Health England, and honoraria from Public Health England and the Royal College of General Practitioners outside the submitted work. Mary O'Kane reports consulting fees from Novo Nordisk and honoraria from Novo Nordisk and Johnson & Johnson outside the submitted work. Samuel J. Dicken is funded via a Medical Research Council grant (MR/N013867/1). Anastasia Z. Kalea, Simon Williams and Erika Wong have nothing to disclose. There are no other declarations of interest.

### TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important aspects of the study have been omitted and

that any discrepancies from the study as planned have been explained.

### PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1111/jhn.13120>

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Plant-based meats in China: a cross-sectional study of attitudes and behaviours

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## Abstract

**Background:** This study investigated potential opportunities or challenges for plant-based meat in the Chinese market. A quantitative framework was applied to determine the current level of familiarity and experience with plant-based meat among Chinese consumers, the proportion of consumers who would try or purchase plant-based meat, which demographics within China are most likely to buy plant-based meat and which attitudes are important in driving the purchase intent of plant-based meat.

**Methods:** A pre-registered cross-sectional online survey ( $N = 1206$ ) was distributed to respondents (matched to China's adult population for gender and age).

**Results:** Respondents reported a variety of dietary identities, with 43.4% reporting that they were reducing or avoiding meat. The majority of respondents (60.1%) said they had eaten plant-based meat at least once before. Of those who said they had never eaten plant-based meat, 41.9% intended to try it and 31.4% intended to purchase it. The strongest attitudinal predictor of plant-based meat purchase intent was perceived healthiness ( $\beta = 0.235$ ,  $p < 0.001$ ), whereas the strongest demographic predictor of plant-based meat purchase intent was age ( $\beta = -0.248$ ,  $p < 0.001$ ).

**Conclusions:** The findings of this study suggest that an approach based on increasing opportunities for trial, as well as appealing to specific attitudinal and demographic predictors of plant-based purchase intent, could prove successful in increasing adoption of plant-based and alternative meat products.

## KEYWORDS

China, consumer behaviour, meat reduction, meat replacement, plant-based meat

## Key points

- Chinese consumers are open to trying and purchasing plant-based meat, despite low existing familiarity with modern plant-based meat products.
- Perception of plant-based meat as healthy was the strongest attitudinal predictor for plant-based meat acceptance followed by the perception of plant-based meat as having a good mouthfeel and food safety advantages.
- Younger respondents were more likely to intend to purchase plant-based meat, and age was the strongest demographic predictor of plant-based meat acceptance.

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- Respondents responsible for preparing food for children; those who were married, living with a partner, divorced or widowed; and those living in bigger cities were also significantly more likely to intend to purchase plant-based meat.
- Potential strategies for driving greater adoption include increasing opportunities for potential consumers to try plant-based meat products, strengthening and appealing to positive perceptions of plant-based meat in marketing and public engagement campaigns and targeting demographics with high levels of acceptance.

## INTRODUCTION

Industrial animal agriculture is increasingly implicated in many of the world's most pressing problems. In addition to contributing to the majority of direct agricultural emissions, animal farming drives more than two-thirds of agricultural deforestation.<sup>1,2</sup> Intensive animal agriculture also provides ideal conditions for pathogens to spread, increasing the risk of epidemics.<sup>3</sup> In response, farmed animals are fed antibiotics and now account for more than two-thirds of global antibiotic consumption.<sup>4</sup> Moreover, farmed animals are conscious, intelligent creatures with the capacity to suffer,<sup>5</sup> and their welfare is often extremely poor in farming.<sup>6</sup> There are compelling reasons to reduce meat consumption for the environment, public health and animal welfare.

Meat consumption is an issue of environmental and public health importance, and it is also an issue of political importance.<sup>7</sup> Food security is of paramount importance to any country's government, and China is now partly reliant on meat imports, especially from Australia and South America.<sup>8</sup> Recent supply shocks, and the Chinese government's rapid response, have demonstrated the importance of a reliable supply of affordable and appealing protein.<sup>7,9,10</sup> The political incentives appear to align with exploring alternatives.

However, most global trends suggest that meat consumption, particularly in developing countries, is increasing rather than decreasing.<sup>11</sup> China, which now accounts for 18% of the global population,<sup>12</sup> has witnessed a significant increase in per-capita meat consumption over the past 10 years.<sup>13</sup> As incomes continue to increase across China, it is predicted that meat consumption will follow suit, with the potential to exacerbate associated issues. In 2016, China's health ministry updated its national dietary guidelines to specify that citizens should eat 40–75 g of meat per day. Commentators noted that, if followed, this would represent a 50% decrease from the projected consumption rate in 2030 and provide substantial benefits to the environment as well as public health.<sup>14</sup>

Alternative proteins, including plant-based meats, have emerged as one of the most promising ways to reduce meat consumption. Plant-based meat emulates the sensory experience of meat products using plant

ingredients and can be substituted directly into familiar meals. Plant-based meat addresses key drivers of food choice, including taste, convenience and familiarity.<sup>15–17</sup> Although 'mock meat' has a long history in Chinese cuisine, modern plant-based meat has primarily been discussed in the context of western consumers to date. Research suggests that Chinese consumers may be particularly open to plant-based meat,<sup>18</sup> yet there remains a knowledge gap concerning the characteristics of Chinese consumers.

The aim of this study is to begin addressing this gap by investigating potential opportunities or challenges for plant-based meat in the Chinese market. The present study is part of a sequential mixed methods design. Phase one used qualitative methods to identify common consumer attitudes among Chinese consumers vis-à-vis plant-based meat.<sup>19</sup> The second phase, reported here, used a quantitative survey to further investigate Chinese consumers' attitudes and behaviours towards plant-based meat.

## MATERIALS AND METHODS

### Study design

The study received ethics approval from the University of Bath's Psychology Research Ethics Committee (PREC 21-011). Utilising an online survey instrument, this study sampled a representative cross-section of the Chinese population. The aim of this research was to begin investigating potential consumer market responses to plant-based meats. Five specific research questions were evaluated in this study.

- 1) What is the current level of familiarity and experience with plant-based meat?
- 2) What proportion of Chinese consumers say they would try plant-based meat?
- 3) What proportion of Chinese consumers say they would buy plant-based meat?
- 4) Which demographics are most likely to buy plant-based meat?
- 5) Which attitudes are important in driving plant-based meat purchase intent?

## Survey instrument and concept definition

The survey instrument was created in English and translated into Chinese by a bilingual co-author. It is available in both languages on the Open Science Framework along with other study materials.<sup>20</sup> The estimated time to complete the survey instrument was 15 min. The survey included the following sections: informed consent; demographics; an introduction to the concept of plant-based meat; questions about respondents' familiarity, attitudes and consumption behaviours (actual and intended) towards plant-based meat; personas; and debriefing. The survey also included two attention-check questions. As an introduction to the concept of plant-based meat, respondents were provided with a definition along with three images of foods in this category (Figure 1).

## Respondents, recruitment and data collection

The survey was programmed and hosted in Qualtrics. Data were collected between 19 April 2021 and 27 May 2021. The sample was recruited from the online survey company Wenjuanxing that sent invitations to its panelists (a non-probability-based sample) to participate in the study. The survey was fielded to respondents with the chosen target demographics in an effort to attain a sample that approximated the adult Chinese population in terms of age and gender. Eligible individuals were those who gave their consent to take part, were at least 18 years of age and correctly answered two attention-check questions.

The survey invitation wording used by Wenjuanxing was as follows: 'Thank you for participating in this market survey! There is no right or wrong answer, just fill in your answers according to your actual situation. Your opinion is very important to us! However, if your answer is not earnest or complete, you will not receive the reward. Providing honest and thoughtful answers to this survey is key to ensuring the success of market research. We and our customers use these research findings as a basis to understand real market conditions and make important decisions, which can impact consumers such as yourself'.

## Measures

### Familiarity

Respondents indicated their familiarity with plant-based meat with three response options: 1 (*not at all familiar*), 2 (*somewhat familiar*) and 3 (*very familiar*). They were asked to do so according to the following directive: 'Before you read this description, how familiar were you with plant-based meat?'

### Consumption

Respondents were asked whether they have eaten plant-based meat with three response options: 1 (*no*), 2 (*yes, I have tried it but not regularly*) and 3 (*yes, I eat plant-based meat regularly*). Depending on respondents' responses to

*One food innovation is called plant-based meat. This type of meat is made entirely from plants and has no animal ingredients. This meat is produced using plant ingredients like proteins, fats, and carbohydrates to mimic the structure of conventional meat, making them closer to meat than traditional soy-based meat alternatives. Recent breakthroughs in producing plant-based meat make these products look, taste, and cook similar to their conventional meat counterparts, allowing them to be used in dishes in much the same way as meat. Several companies have launched products in grocery stores and restaurants.*



FIGURE 1 Stimulus text and images shown to respondents

this question, they were shown different questions in the 'intentions' section.

## Attitudes

On a five-point numerical scale with anchors on either end, respondents reported what they think of plant-based meat in 12 areas: health, naturalness, tastiness, safety, convenience, affordability, animals, the environment, nutritiousness, mouthfeel, coolness/trendiness and realness.

## Intentions

Using a five-point scale anchored with 'definitely no' and 'definitely yes' on either end, respondents who indicated that they had not previously eaten plant-based meat were asked whether they would try plant-based meat and whether they would buy plant-based meat. Respondents who indicated that they had already eaten plant-based meat were asked whether they would buy plant-based meat.

## Frequency

Respondents were asked to indicate on a six-point scale how frequently they would eat plant-based meat. Those who indicated that they had not eaten plant-based meat were asked about how frequently they would eat it, whereas those who indicated that they already eat plant-based meat reported how often they currently do so. The frequency scale was: 1 (*never*), 2 (*less than once per month*), 3 (*one to*

*three times per month*), 4 (*one to three times per week*), 5 (*four to six times per week*) and 6 (*every day*).

## Data cleaning and weighting

The survey received 1807 responses. According to the pre-registration plan, respondents who were aged below 18 years ( $n=5$ ) or who had failed either of the two attention-check questions ( $n=233+140$ ) were excluded. Responses with missing demographic data relevant to weighting were also excluded ( $n=250$ ), leaving a final sample size of  $N=1206$  valid responses, of which  $n=1021$  completed the full survey (note that some exclusions are counted twice). Post-collection weighting was used to bring the sample further in line with the target proportions of age and gender of the broader Chinese population, as measured in the latest census.

Table 1 presents the age distributions of the sample, broken down by gender, both before and after weighting, and grouped together according to the fielding ranges used by the panel. The table also lists the weight applied for each of the demographic segments, based on census figures.<sup>21</sup> As shown, weightings were applied such that the final sample was demographically similar to the Chinese population in terms of age and gender. Income ranges are presented in Chinese Yuan (RMB), whereas the areas listed are the former Greater administrative areas of China, now often referred to as 'statistical regions'; 'City tier' refers to an unofficial hierarchical classification of Chinese cities according to population size, income level and infrastructure. Tier 1 includes the biggest cities such as Beijing and Shanghai, whereas Tier 4 includes the smallest cities in the sample, such as Zhanjiang and Yueyang.

TABLE 1 Age by gender groups for the sample, before/after weighting, and compared to the Chinese adult population

Group	N before weighting	Percentage before weighting	Weight	N after weighting	Percentage after weighting	Percentage in adult Chinese population
Men 18–24	70	5.8	1.00	70	5.8	5.8
Men 25–39	179	14.8	1.03	184	15.3	15.4
Men 40–54	334	27.7	0.50	167	13.8	13.9
Men 55+	63	5.2	2.95	186	15.4	15.4
Women 18–24	96	8.0	0.63	60	5.0	5.1
Women 25–39	182	15.1	0.94	171	14.2	14.3
Women 40–54	242	20.1	0.66	160	13.3	13.3
Women 55+	30	2.5	6.46	194	16.1	16.2
Other gender 18–24	2	0.2	1.34	3	0.2	Unknown
Other gender 25–39	2	0.2	1.34	3	0.2	Unknown
Other gender 40–54	3	0.2	1.34	4	0.3	Unknown
Other gender 55+	3	0.2	1.34	4	0.3	Unknown

## Analysis

Before data collection, a pre-analysis plan for the study was pre-registered on the Open Science Framework,<sup>20</sup> which also houses deviations from the pre-analysis plan as well as all data used in the study. We conducted a series of descriptive analyses with the aim of elaborating on the sample's demographics and dietary behaviours. In addition, we reported the percentage of consumers who are familiar with plant-based meat, how frequently they tend to eat it, their general attitudes towards plant-based meat and their behavioural intentions vis-à-vis future consumption. Finally, two multiple linear regressions were conducted on the data, showing which demographic factors and which of the 12 attitudinal perceptions predict plant-based meat purchase intent (Table 2). Data were analysed using IBM's Statistical Package for the Social Sciences (SPSS), version 26, using descriptive and inferential statistics, with a significance level set to  $p < 0.05$ .

## RESULTS

### Demographics

A total of  $N = 1206$  respondents participated in the study after data cleaning. Their demographic characteristics are presented in Table 3.

Although our weighted sample was demographically similar to the age and gender of the Chinese population, we found an overrepresentation of urban and more highly educated respondents. This has also been observed in similar studies conducted through online samples in China.<sup>18,22</sup> This may be due to limited internet

TABLE 2 Demographic characteristics of the sample

	Std $\beta$	$p$
Constant	0.416	–
Healthy*	0.235	<0.001
Natural	0.014	0.654
Mouthfeel*	0.185	<0.001
Safe*	0.122	0.001
Convenient	–0.007	0.803
Affordable*	0.058	0.019
Animal friendly*	0.112	<0.001
Eco-friendly	0.023	0.480
Nutritious*	0.067	0.042
Tasty	0.018	0.604
Cool/trendy*	0.109	<0.001
Real	–0.017	0.572

Notes:  $F(12,1057) = 74.819$ ,  $p < 0.001$ ,  $R^2 = 0.459$ , adj  $R^2 = 0.453$ . Significant predictors ( $p < 0.05$ ) are indicated with an asterisk.

TABLE 3 Regression showing impact of attitudes on purchase intent

Demographic characteristics	Percentage unless otherwise indicated	
Mean age (range; in years)	43.89 (18–102)	
Gender	Female	48.5%
	Male	50.4%
	Other	1.1%
Education	Less than high school	4.1%
	High school	13.1%
	University (bachelor's degree) and vocational college	76.1%
	Master's programme	5.0%
	PhD programme	1.7%
Income	0–36,000	11.2%
	36,000–144,000	35.3%
	144,000–300,000	33.5%
	300,000–420,000	10.4%
	420,000–660,000	6.3%
	660,000–960,000	1.2%
	More than 960,000	2.1%
Region	Huabei area (north China)	22.7%
	Dongbei area (northeast)	8.0%
	Huadong area (east China)	30.7%
	Zhongnan area (central and south)	21.3%
	Xibei area (northwest)	5.0%
	Xinan area (southwest)	12.3%
	City tier	T1
T2		33.4%
T3		14.4%
T4		13.3%
Other <sup>a</sup>		6.2%
I don't know		3.4%
Relationship status	Single	14.8%
	In a relationship	4.7%
	Married or living with partner	76.9%
	Divorced or widowed	3.5%
Responsible for preparing food for children at home	Yes	49.8%
	No, I do not live with children	37.3%
	No, I live with children but somebody else prepares the food	12.9%

<sup>a</sup>This includes rural areas below T4.



access for some groups, such as more rural and less-educated populations and the requirement that respondents be 18 or above to participate in the survey.

## Dietary behaviours

As shown in Figure 2, respondents reported a variety of dietary identities, including 55.7% omnivore/meat-eater (no restrictions on eating animal products); 38.8% reductarian, flexitarian or semi-vegetarian (reducing meat consumption or eating it only occasionally); 1.9% pescetarian (plant-based foods, eggs, dairy and fish); 2.0% vegetarian (plant-based foods, eggs and dairy); 0.7% vegan (only plant-based foods); and 0.8% another diet. A total of 43.4% of respondents self-reported that they were reducing or avoiding meat.

Respondents reported buying food from a variety of sources as follows (see Figure 2): 86.4% supermarkets, 73.4% wet markets, 51.9% restaurants, 34.7% canteens at work, 29.6% takeaway, 24.6% online groceries and 25.1% fast-food outlets. Respondents reported eating animal products and alternatives at various frequencies. The most prevalent food category was eggs, with 89.8% of the sample indicating that they consumed this food in the last month. This was followed by red meat eaten by 81.3% and poultry consumed by 81.1% of the sample. The least common food was insects, consumed by 0.8% of respondents.

## Familiarity, attitudes and intentions

### Familiarity and consumption

At the onset of the study, 30.4% of the sample indicated that they were not at all familiar with plant-based meat,

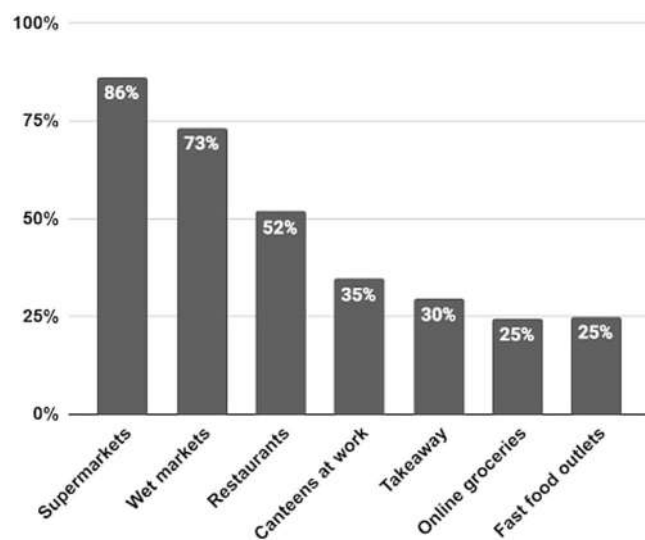


FIGURE 2 Food purchase locations in the sample

63.2% reported they were somewhat familiar and 6.4% said they were very familiar. Respondents were also asked whether they had eaten plant-based meat, with 39.9% indicating 'no', 54.5% reporting they have tried it but not regularly and 5.6% noting they eat plant-based meat regularly.

### Attitudes

Figure 3 presents a radar plot with Chinese respondents' mean attitudes towards plant-based meat across 12 criteria. The overall mean ratings of the different items are represented such that points near the centre of the circle represent more negative opinions and points near the outside of the circle represent more positive opinions. Respondents generally rated plant-based meat as being good for animals and the environment. They also tended to rate plant-based meat as convenient, healthy, safe and cool/trendy. The ratings for 'real' and 'natural' were on the lower end, as was the rating for mouthfeel. The lowest rating was affordability. All mean ratings were above the midpoint of 3.

### Intentions

As shown in Figure 4, the majority of Chinese respondents (60.1%) say they have eaten plant-based meat before at least once, whereas 39.9% say they have never eaten plant-based meat. Of those who say they have never eaten plant-based meat, 41.9% say they would be open to trying it, with 19.7% saying they would not try it (38.4% were neutral). Further, 31.4% of those who have never eaten plant-based meat before said they would buy

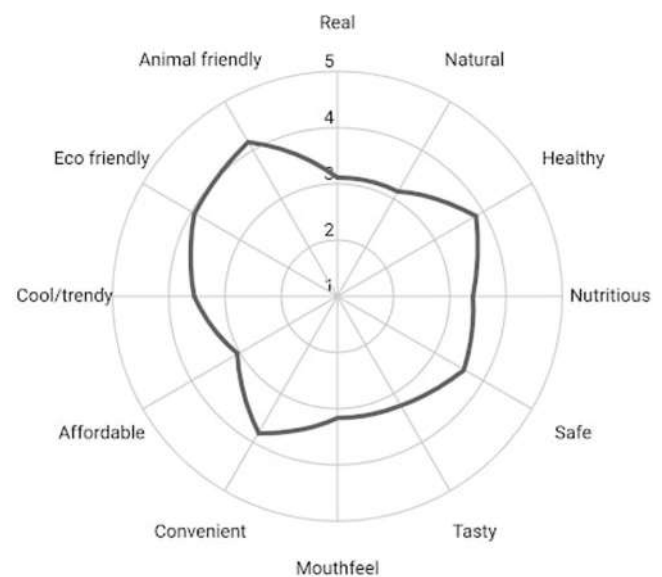


FIGURE 3 Mean attitudes towards plant-based meat

plant-based meat, with 27.4% saying they would not buy it (41.1% were neutral). This is compared to 47.8% of those who have eaten plant-based meat before saying they would buy it, with just 16.2% saying they would not (36.0% were neutral).

### Attitudes and demographics associated with acceptance

The strongest attitudinal predictor was perceived healthiness. This was followed by perceived mouthfeel and food safety. Additional significant predictors in the model were nutritiousness, affordability, being beneficial for animals and coolness/trendiness.

The strongest demographic predictor was age, with younger respondents being more likely to intend to purchase plant-based meat. In addition, those responsible for preparing food for children; individuals who are married, living with a partner, divorced or widowed; and those living in bigger cities were significantly more likely to intend to purchase plant-based meat. Vegans were less likely than omnivores to purchase plant-based meat, whereas no significant difference was found for other dietary groups. Other factors, including education, income and gender, were not predictive of plant-based meat purchase intent (Table 4).

## DISCUSSION

This study aimed to explore the nature of the market for plant-based meat in China, conducting a census-balanced survey of the Chinese population to address current knowledge gaps. We discuss the factors that we found to correlate with purchase intent and identify potential areas for future scholarly research, as well as opportunities for stakeholders who want to increase the adoption of plant-based meat (including advocates, ecosystem builders and alternative protein companies).

### Familiarity and trial intent

Although familiarity has been linked with increased willingness to eat plant-based meat,<sup>18</sup> the findings of this study suggest that Chinese consumers may be open to trying these products, despite low familiarity. Although approximately 94% of Chinese consumers stated they were only somewhat (63.2%) or not (30.4%) familiar with plant-based meat, we found that 42% were open to trying

TABLE 4 Multiple regression showing which demographic factors predict higher plant-based meat purchase intent

	Std B	p
Constant	4.061	–
Age*	–0.248	<0.001
Dummy: flexitarian	0.033	0.275
Dummy: pescetarian	0.053	0.066
Dummy: vegetarian	–0.053	0.097
Dummy: vegan*	–0.097	0.006
Dummy: other diet	–0.021	0.474
Education	–0.074	0.025
Income	–0.038	0.213
City tier*	–0.071	0.024
Dummy: female	–0.043	0.139
Dummy: other gender	–0.019	0.528
Dummy: in relationship	0.055	0.083
Dummy: married/cohabiting*	0.110	0.026
Dummy: divorced/widowed*	0.119	0.002
Dummy: has kids, cooks*	0.225	<0.001
Dummy: has kids, doesn't cook	0.016	0.628

Notes:  $F(15, 1054) = 13.456$ ,  $p < 0.001$ ,  $R^2 = 0.161$ , adj  $R^2 = 0.149$ . Significant predictors ( $p < 0.05$ ) are indicated with an asterisk.

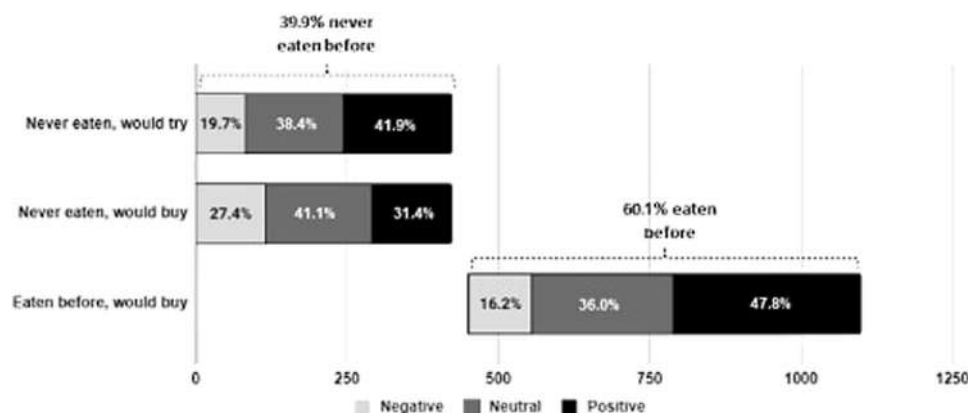


FIGURE 4 Trying/buying intentions for those with/without prior experience with plant-based meat

it, if they had not eaten it before. In addition, of the respondents who had not tried plant-based meats and were willing to try plant-based meat, half stated that they were not at all familiar with it. One explanation for this could be lower reported levels of food neophobia in China. McKenzie et al.<sup>23</sup> found that Chinese adults tend not to be high in food technology neophobia, whereas Bryant et al. found that China had higher levels of plant-based meat acceptance compared to the United States and lower levels of food neophobia compared to India.<sup>18</sup> This suggests that, although awareness-raising marketing campaigns for plant-based meat may be useful, a more effective approach, given high trial intent and low food neophobia, may be to focus on directly activating new customers by increasing opportunities for trial.

### Consumption and purchase intent

Consequently, we also found that consumers who have tried plant-based meat have higher purchase intent (47.8 compared to 31.4% for those who have not tried), further reinforcing the potential effectiveness of increasing trial opportunities. It is also promising for plant-based meat producers that plant-based meat products seem to be able to retain consumers, with only 16.2% of those who had tried it saying that they would not buy it again in the future. This is somewhat consistent with results from a study conducted by the consultancy Data100, which found that 89% of consumers were somewhat or very willing to purchase plant-based meat after trying it.<sup>24</sup> However, these figures are not directly comparable given the use of different point scales. Further, we should consider the likely effect of selection bias, because those who have already eaten plant-based meats are presumably the type of individuals who are more likely to eat them in the future.

### Attitudes and purchase intent

The study found seven attitudinal predictors of purchase intent, with healthiness being the most important. This is consistent with Bryant et al.'s observation that perceived healthiness was one of the strongest predictors of plant-based meat acceptance in China.<sup>18</sup> Other predictive perceptions were mouthfeel, safety, nutritiousness, affordability, being animal friendly and coolness/trendiness (in order of effect size, strongest to weakest). This suggests that strengthening and appealing to these perceptions of plant-based meat in marketing and public engagement campaigns may be effective in driving greater adoption.

Conversely, perceptions of naturalness, realness, tastiness, convenience and eco-friendliness were not predictive of purchase intent. Naturalness, realness and taste seem particularly surprising as they are often cited as objections

to the adoption of plant-based meat.<sup>25</sup> It is also interesting that eco-friendliness, although rated positively like animal friendliness, is not predictive of purchase intent. This is consistent with Cao's<sup>26</sup> finding that 54% of Chinese consumers believed that people choose vegetarianism out of concern for animal welfare, whereas only 21% cited 'other reasons' (which could include environmental protection). Similarly, when asked about the benefits of vegetarianism, 68% cited 'not taking life', whereas 49% cited environmental protection. This seems to suggest that, in China, messaging around animal welfare could be more effective in driving the adoption of plant-based meat than environmental concerns.

The strength of consumer perceptions was also observed to differ across the attitudinal predictors. Of the seven predictors, only animal friendliness ( $M = 4.17$ ) and healthiness ( $M = 3.84$ ) were perceived quite positively by consumers, whereas safety, coolness/trendiness and nutritiousness were somewhat positively perceived, with mean ratings between 3.4 and 3.6 out of 5.

Finally, consumers had neutral perceptions of mouthfeel and affordability (with mean ratings between 3.0 and 3.3). In fact, all perceptions besides animal friendliness were rated between 3.0 and 4.0, with half of them rated between 3.0 and 3.5, suggesting that Chinese consumers may currently have generally neutral views towards plant-based meat. This may be in part explained by the low familiarity (94% somewhat or not at all familiar) with plant-based meat and may indicate a promising opportunity for stakeholders to shape Chinese consumers' perceptions of plant-based meat in the formative stages. However, this may also be somewhat affected by Chinese respondents having a greater tendency to select an average response.<sup>27</sup>

### Diets, demographics and purchase intent

Vegans were the only type of meat avoiders who differed significantly in purchase intent from meat-eaters, being less likely to purchase plant-based meats. This may be due to a significant portion of vegans in China adopting their diet for religious and philosophical reasons (e.g., Daoists and Buddhists), with aspirations of purity, simplicity and minimising indulgence, which was reflected in both the qualitative phase of this study and the academic literature.<sup>26</sup> These aspirations are frequently at odds with the perceived (and sometimes actual) features of plant-based meat, such as unnaturalness and high additive content.

The study found a surprisingly high number of respondents following meat-reduced diets. Whereas approximately 1 in 20 (4.6%) avoided meat completely as part of a pescetarian, vegetarian or vegan diet, a further two-fifths (38.8%) followed a flexitarian or semi-vegetarian diet, reducing their meat consumption or eating it only occasionally. This corresponds to 43.4% reducing or eliminating meat consumption in China,

which is higher than the recently observed levels in European countries.<sup>28,29</sup> This may reflect the growing 'new wave vegetarianism' in China, which pays 'homage to Buddhist and other Chinese traditions of meat avoidance' but also incorporates 'multiple new motivations including health, environment and animal welfare',<sup>27</sup> and may be further reinforced by the nascent but growing animal protection movement in China, which has been amplified by the use of Chinese social media.<sup>27,30</sup>

In driving increased adoption of plant-based meats, another promising group of customers comprises those who have never eaten plant-based meat before but would try it. This group represented 17.1% of the sample (41.9% of 39.9%). Compared to the overall sample, this segment was more likely to identify as omnivores (72.5 compared to 55.7%) and slightly less likely to be strict meat avoiders (2.2 compared to 4.6%). This is consistent with survey data from European consumers, which show that vegetarians and vegans are more likely than meat-eaters to eat meat alternatives like tofu and tempeh, whereas meat-eaters are more likely to eat plant-based meat.<sup>31</sup> This suggests that having a greater focus on meat-eaters rather than vegetarians could be a good strategy for reaching new markets. Perhaps crucially, many in this group (49.7%) were not at all familiar with plant-based meat, indicating that marketing strategies aiming to raise awareness of these products among meat-eaters could be effective at growing the market.

Demographically, it is interesting to note that commonly assumed drivers such as education, income and gender were not predictive of plant-based meat purchase intent. Factors that were associated with higher purchase intent towards plant-based meat included being younger, living in bigger cities, being married or divorced/widowed and being responsible for preparing food for children at home. Although there was an expectation to find higher appeal among younger and more urban consumers, the findings regarding married/divorced individuals and parents were unexpected. Indeed, it seemed from the qualitative stage of the research as though married parents were more likely to prefer animal products for their children's health. There are several potential explanations for this finding that would require further study. It may be that although parents would prefer to feed animal products to children, they are open to eating plant-based products themselves. This could be due to the perceived healthiness of plant-based diets for adults and the convenience of plant-based products. This would be consistent with the high ratings for the healthiness and convenience of plant-based meat.

## Limitations

This work has some limitations. First, our study cannot be generalised across the entire Chinese population. Although in line with the age and gender balance of the

Chinese census, our weighted non-probability-based sample, like other similar online studies conducted in China,<sup>18,23</sup> has an overrepresentation of urban and more highly educated respondents. However, as noted by Bryant et al., this population likely represents those who will have access to plant-based meats in the near future.<sup>18</sup> Second, there is variability in response selection on Likert-type scales across cultures, where some cultures have a tendency towards the more extreme response categories, whereas others provided more qualified responses.<sup>32</sup> For instance, respondents in Asian cultures are known to use the midrange of a response scale as an expression of modesty.<sup>32</sup> A study by Zax and Takahashi<sup>33</sup> found that Japanese respondents provided less extreme ratings than their American counterparts. Another limitation is that online self-reported survey data are limited in terms of their ability to capture real behaviour given the limits of memory recall. Such studies also involve risks of social desirability bias, non-response bias and respondent quality issues. As well, given the study's non-causal design, the results can speak only to associations. Finally, respondents' understanding of plant-based meat products as defined in the survey was not tested. Although a detailed explanation of plant-based meat was provided, including photos of sample products, it would be helpful in the future to validate respondents' understanding at the survey outset.

## CONCLUSION

This study begins to fill the knowledge gap regarding the nature of the Chinese market for plant-based meat. It found a surprisingly high proportion of Chinese consumers who identified as meat reducers or avoiders. The findings also showed that the majority of Chinese respondents say they have eaten plant-based meat before at least once. Of those who say they have never eaten plant-based meat, a notable proportion report they intend to try it or purchase it. The strongest attitudinal predictor of plant-based meat purchase intent was perceived healthiness, whereas the strongest demographic predictor was being younger. The findings of this study suggest that an approach based on increasing opportunities for trial, as well as appealing to specific attitudinal and demographic predictors of plant-based purchase intent, could prove successful in increasing adoption.

## AUTHOR CONTRIBUTIONS

All authors contributed to the study design and ongoing oversight of the research. Christopher J. Bryant and Jah Ying Chung collected the data. Christopher J. Bryant analysed the data. Christopher J. Bryant and Kathryn E. Asher drafted the manuscript. All authors edited the manuscript and approved the final version for publication.



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## CONFLICT OF INTEREST

Jah Ying Chung does paid and pro bono research with organisations in the farmed animal welfare and alternative protein spaces. Christopher J. Bryant does paid and pro bono research with organisations in the alternative protein and meat reduction space. Kathryn E. Asher has researched and worked in the area of plant-based consumption for many years.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in China Plant-Based Meat Consumer Insights Study at <https://osf.io/ts9bh/>.

## ETHICS STATEMENT

The study received ethics approval from the University of Bath's Psychology Research Ethics Committee (PREC 21-011).

## TRANSPARENCY DECLARATION

The authors confirm that this is an honest, accurate and transparent account of the study being reported. The authors confirm that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

## PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1111/jhn.13092>.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# The role of dietetics accreditation standards in supporting practice-ready graduates – a policy analysis

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## Abstract

**Background:** Despite clear evidence that accreditation has the potential to shape the future of graduate outcomes and health professions, little research has examined accreditation policy within dietetics and whether it achieves its aims. This study aimed to interpret the purpose and positioning of dietetic accreditation standards internationally.

**Methods:** This study drew on Yanow's interpretive policy analysis approach. Countries with similar dietetics education and accreditation systems were selected for inclusion in this study, including Australia, Canada, New Zealand, the United Kingdom and the United States. A purposive sample of participants involved in the accreditation process were identified and invited to participate in semistructured interviews. Accreditation standards from all countries were collected. Coding of text for purpose and meaning was undertaken. Codes were then grouped into categories and then themes, in line with the interpretive policy analysis approach that aims to seek meaning from the policy and identify conflicts.

**Results:** A total of 8 interviews and 11 accreditation standard documents were analysed from across the five countries. The analysis of data showed that the purpose of accreditation was protecting public safety by producing safe and effective dietetic graduates and supporting universities to achieve this. Focusing on input- versus outcome-based education was a key conflict.

**Conclusions:** There is a unified purpose of accreditation internationally which may support global mobility of the dietetics workforce. Focusing more on outcome-based standards may support the development of dietetics graduates better equipped to meet future needs.

## KEYWORDS

accreditation standards, dietetics education, outcome-based education, qualitative research

## Key points

- Dietetics accreditation determines the ability of education providers to meet the accreditation standards set by regulators to support dietetic workforce preparation.
- Using policy analysis of participant interviews and key artefacts of international dietetics accreditation systems showed that accreditation served to support universities and protect the public, safeguarding the quality of dietetic graduates.
- A key tension internationally was the focus on inputs versus outcomes inherent in the policy.

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## INTRODUCTION

Accreditation has been defined as ‘the process of formal evaluation of an educational programme, institution or system against defined standards by an external body for the purposes of quality assurance and enhancement’.<sup>1</sup> Accreditation is both the policy and processes that guide the assessment of an education provider's course/programme to meet the accreditation standards set by the relevant regulator. The accreditation standards include demonstrating that graduates have been assessed as achieving relevant competency standards (sometimes referred to as practice standards or capabilities). The fundamental value underpinning accreditation systems is to ensure that graduates are both safe and effective in their practice to meet the current and rapidly evolving healthcare systems. Creating a safe and effective health workforce is essential to achieving optimal health outcomes of current and future populations.<sup>1,2</sup> Accreditation has been poised as holding health professions accountable and acting to instil public confidence in the safety of health professions.<sup>1</sup> Yet there is limited evidence on whether accreditation systems fulfil this role in preparing work-ready health profession graduates.

Historically, accreditation systems for health professionals have focused on input-based or time-dependent educational models. In 2010, the Lancet Commission on Education of Health Professions for the 21st century requested global change in the education of health professions to better meet the needs of the health workforce.<sup>3</sup> This report suggested a shift from input- to outcome-based education. Outcome-based education is founded on the principle that graduate outcomes, or articulated competencies, guide all curriculum decisions and processes.<sup>2</sup> If the goal of accreditation is to create health professionals who are safe, effective and able to meet the current and emerging needs of the workforce, there is indeed logic in assessing the quality of education programmes utilising metrics of graduate outcomes. This focus on graduate competency has been suggested to have benefits such as greater accountability to the public, fostering learner centredness, allowing for greater flexibility and innovation in curriculum and better able to meet the current and emerging health needs of the population.<sup>2,4</sup> Evidence related to the value of outcome-based systems is still in its infancy; however, current evidence supports this shift, which is seen to foster continual quality improvement over traditional input models of education (e.g., staff to student ratios, hours of practical experience) that are limited to quality assurance. Focusing on quality improvement may be better positioned to cultivate educational innovation and meet the evolving needs of the health workforce<sup>5</sup>; yet there is limited evidence exploring the value of outcome-based education or analysis of how well accreditation standards and processes support quality improvement in programmes.

Despite evidence that accreditation systems across health professions share common elements and principles regardless of jurisdiction and location,<sup>1</sup> accreditation systems within nutrition and dietetics have been scarcely studied. Dietetics accreditation in Australia, Canada, New Zealand, the United Kingdom and the United States typically has a set of standards that education programmes are assessed against by an accreditation team. An Australian study has highlighted competency standards as maintaining a standard for dietetic practice over time.<sup>6</sup> Despite the gradual transition to outcome-based models, dietetic accreditation standards internationally continue to articulate conditional requirements such as the inclusion of a strong bioscience foundation and time required for practicum. Such elements have been suggested as potentially limiting educational innovation, particularly in faculties aiming to adapt to the rapidly changing dietetic workforce.<sup>6</sup> Furthermore, no studies have directly analysed if variations exist internationally within dietetic accreditation systems and the value this has in supporting international workforce mobility.

This study aimed to interpret the purpose and positioning of dietetic accreditation standards internationally. More specifically, the research aimed to answer the following research questions: What purpose is espoused by accreditation standards processes? Why is this purpose framed this way? How is dietetics accreditation positioned as input versus output? Does the purpose or positioning differ internationally? Awareness of this purpose will support understanding of the benefits and challenges of accreditation for dietetics internationally.

## METHODS

This study employed an interpretive approach guided by Yanow's interpretive policy analysis.<sup>7</sup> Policy analysis aims to establish ‘how and why certain policies come to be developed in particular contexts, by who, for whom, based on what assumptions and with what effect’ (p. 97).<sup>8</sup> Although there are several methods of policy analysis, Yanow's interpretive approach focuses on seeking meaning behind the policy.<sup>7</sup> This approach recognises that the framing of the policy problems shapes the array of possible policy responses.<sup>9</sup> As this study focused on deriving meaning from the purpose and processes of dietetic accreditation, Yanow's four-step method was deemed ideal: (1) identifying the artefacts, (2) identifying relevant participants and communities, (3) identifying the meanings being communicated and (4) identifying the points of conflict and their sources (i.e., different interpretations).<sup>7</sup>

Researcher reflexivity was employed throughout the data collection and analysis process. The researchers were all female dietitians with different relationships to accreditation: a senior dietitian involved in the accreditation of Australian programmes with experience in education research, a postdoctoral dietitian experienced

in interpretive policy analysis and a student dietitian directly experiencing dietetic education during the study. These different perspectives were embraced during the collection and analysis of the data.

## Step 1: identifying the artefacts

A purposive sample of countries with similar dietetics education and accreditation systems were selected for inclusion in this study. The accreditation bodies included the British Dietetic Association (BDA) and the Health and Care Professions Council (HCPC) (United Kingdom), the Accreditation Council for Education in Nutrition and Dietetics (United States), the Australian Dietetics Council (Australia), the Partnership for Dietetic Accreditation and Practice (Canada) and the Dietitians Board New-Zealand (New Zealand). All accreditation documents associated with these accreditation bodies were identified and selected for inclusion in the study. This included accreditation standards and process or policy documents (Table 1).

## Step 2: identifying relevant participants and communities

In addition to documents, interviews with experienced accreditation stakeholders from the relevant

accreditation authority were conducted. Stakeholders were identified based on having a primary work role in managing and/or administering the accreditation policy. Malterud and colleagues advise using the information power principle, which is based on study aim, sample specificity and analysis approach. Applying this principle, a small sample size was considered adequate.<sup>10</sup> In addition to the small, specific sample identified initially, snowballing was utilised in which participants were invited to suggest other individuals with knowledge relevant to our research aims. Stakeholders were invited to participate in an individual or group virtual interview via videoconference. Invitations were sent out via email in September 2020. All participants were informed of the research aims and objectives via an explanatory statement, and signed consent was obtained from all participants. Ethics approval was granted from the Monash University Human Research Ethics Committee.

Two authors conducted the interviews (S. M. or C. P.). The researchers did not have existing relationships with interview participants, with the exception of C. P., and in this case, S. M. conducted the Australian interviews to ensure participants were comfortable to speak freely. A semistructured interview guide informed the questions. Interview questions evaluated each country's accreditation process; who is involved in accreditation, as well as their accreditation processes; views of the purpose of accreditation; and how well it achieves the

TABLE 1 Number of accreditation staff participants interviewed and accreditation documents collected per country

	Interview participants	Accreditation documents
<b>Australia</b>	$n = 2$	Accreditation Standards for Dietetics Education Programs v2.0, 2017 $n = 1$
<b>Canada</b>	$n = 2$	Accreditation Standards for Dietetics Education Programs in Canada $n = 1$
<b>New Zealand</b>	$n = 1$	Guidelines for Accreditation of New Zealand Dietetic Education Programmes, 2018 $n = 1$
<b>United Kingdom</b>	$n = 2$	<i>British Dietetics Association – A Curriculum Framework for the Pre-registration Education and Training of Dietitians</i> , Revised Edition 2020 Health and Care Professions Council (HCPC) – Standards for Education and Training Guidance 2017 $n = 2$
<b>United States</b>	$n = 1$	Accreditation Council for Education in Nutrition and Dietetics <ul style="list-style-type: none"> <li>• Accreditation Standards for Nutrition and Dietetics Coordinated Programs, 2019</li> <li>• Accreditation Standards for Nutrition and Dietetics Internship Programs, 2018</li> <li>• Accreditation Standards for Nutrition and Dietetics Didactic Programs, 2018</li> <li>• Accreditation Standards for Nutrition and Dietetics Technician Programs</li> <li>• Accreditation Standards for Nutrition and Dietetics Foreign Education Programs, 2018</li> <li>• Accreditation Standards for Nutrition and Dietetics International Dietitian Education Programs, 2018</li> </ul> $n = 6$

needs of the future health system and population needs (Table 2). The interviews were conducted via Zoom videoconferencing (Zoom video communications Inc., 2022) between September and November 2020. Interviews lasted between 40 and 60 min and were audio recorded and transcribed verbatim.

### Steps 3 and 4: identifying the meanings being communicated and identifying the points of conflict and their sources

Yanow's concepts of 'symbolic language' and 'symbolic objects' were used to analyse the 'objects', in this case policy documents, and 'language', documents and interviews. Category analysis was conducted initially applying a coding process whereby sections of text in the interview and documents were coded or labelled to create categories. Two authors coded all interviews and documents independently using these categories. During this process the focus was on identifying the meanings being communicated,<sup>7</sup> in particular commonality between codes in the category, different meanings of the categories and differences between categories across documents and interviews as recommended in interpretive policy analysis.<sup>7</sup> The authors then came together to interpret the categories and the purposes espoused by accreditation standards and processes and reasons why purpose was framed this way. Data analysis was facilitated using NVivo 11 software (QSR International Pty Ltd, Hawthorn East, Victoria, Australia, 2022). In addition, purposes were compared across countries to identify any differences in purposes internationally. The findings were presented as a summary back to participants via email, with positive affirmation of this summary received.

## RESULTS

A total of seven interviews were conducted ( $n = 6$  individual,  $n = 1$  group), with eight participants representing all key stakeholders involved in the accreditation of dietetic programmes in Australia, Canada, New Zealand, the United Kingdom and the United States. No stakeholders declined or withdrew from the study. Two of the participants were interview based on previous participant recommendations. A total of 11 accreditation documents were collected and analysed (Table 2). Two key purposes of accreditation were identified: (i) safety, effectiveness and quality of healthcare and (ii) support to universities; and one key issue underpinning the meaning of accreditation found (i) input versus outcomes. No differences in purpose or meaning across countries were identified.

### Safety, effectiveness and quality of healthcare

The data identified that the primary purpose of accreditation internationally lies in the interest of public safety, whereby assuring the quality of dietetic education programmes will ensure graduates who are safe to practice and able to meet the relevant standards. Internationally, the standards were consistent in their aim to create graduates able to provide safe, effective and consistent healthcare to meet the current and emerging health needs of their patients and community.

We want to make sure that the graduates that are coming from these courses ... [are] safe to practice and providing the correct nutrition information. (Participant A)

Mechanisms for ensuring the quality of the education programmes included specifying strict entry requirements,

Question topic	Justification and alignment with interpretive policy analysis
Role in accreditation of dietetics programmes	Meaning behind the policy communicated Different interpretations
Relationship between the professional association and accrediting council/board	Identifying the points of conflict Different interpretations
Health and nutrition need of the public in country	Meaning and purpose behind the policy communicated – alignment with outcome
Needs reflected in the dietetics accreditation standards	Identifying the points of conflict Different interpretations
Interests are being served by current accreditation policy	Meaning behind the policy communicated
Resources for accreditation	Meaning behind the policy and purpose

TABLE 2 Interview question topics and alignment logic with Yanow's interpretive policy analysis



for example, academic capability and English proficiency, as well as quality programme governance, curriculum and assessment.

Interviews highlighted that one of the ways in which accreditation served to protect the public was by preventing unqualified practice. Regulation of the dietetics profession was perceived as the solution to the large amount of nutrition misinformation that is disseminated by self-proclaimed experts lacking appropriate qualifications. Accreditation was reported to strongly reflect the interest of the dietetic profession, whereby it served to ensure those eligible for entry into the profession have evidence-based education. Being eligible for registration (or equivalent) after completion of the education was a mechanism to recognise and safeguard the identity of dietitians as experts in nutrition and uphold a professional standard to prevent nutrition misinformation.

There is so much out there on social media where there are people giving nutrition advice ... alluding to the fact that they have ... some sort of credentialing in that area.... There's so much out there it scares me. (Participant A)

By assuring the quality of dietetic programmes, accreditation supported students in promising that accredited courses will equip them with the competencies required to be eligible to enter the workforce, find employment and thrive in the health workforce into the future. This included obtaining the necessary credential or registration by the local or national regulation body. By providing students with quality staff, teaching and learning resources, accreditation intended to ensure that graduates have the required capabilities for practice. Having standards around staffing profiles aimed to uphold professional identify and ensure staff teaching in the programmes had the required experience in the practice of dietetics.

Some participants criticised accreditation standards for not being timely or responsive enough to reflect workforce needs. It was reported that accreditation standards had a role in balancing the fostering of education innovation with the needs of the current and future workforce and assuring the safety of graduates. Many participants reflected that the programme failed to evolve rapidly with changing workforce needs and continued to focus disproportionately on medical nutrition therapy and not for emerging work roles.

I think a lot of students will be very well prepared to go into a clinical role ... there are so many new areas that students don't feel equipped to go work in. (Participant B)

## Support for universities

Internationally, accreditation was described as being valuable to universities. The standards were described as a point of leverage for dietetic departments to advocate to their universities for funding, resources and staffing. Interview participants narrated stories of being unable to be appointed to academic positions due to local funding restrictions and then using accreditation standards specificity around staffing to enable them to be appointed to positions, including senior positions, due to the requirements laid out in the standards.

What I've seen in the past years, when you don't have a minimum, the institution [university] will cut and cut and cut ... [accreditation] acts as a leverage to get what [we] need. (Participant D)

Some reported that accreditation served universities by providing an opportunity for review and quality improvement. Quality improvement was an important element of all accreditation standards. However, Canada, the United States and the United Kingdom stood out in the emphasis placed on quality improvement and self-reflection of dietetic programmes to ensure continuously being able to meet emerging healthcare needs. This was reflected in the transparency of programme quality to the broader community, publishing conditions on publicly available websites.

Accreditation stimulates and supports quality assurance and continuous improvement. The processes of accreditation recognise the ever-changing nature of the dietetic profession, encourages ongoing review and promotes educational innovation and excellence. (Accreditation Standards for Dietetics Education Programs in Canada)

Some participants criticised whether quality improvement and self-reflection goals of accreditation were currently being met. Participants doubted that universities viewed accreditation as an opportunity for self-review due to the onerous nature of the accreditation process. The transparency of the accreditation process was also reported as a point of conflict between universities and accreditation bodies by many participants. Some participants reflected that this may be in the interest of the university, whereby it may act to reduce the stigma associated with having conditions for accreditation. In addition, conditions were viewed as mechanisms to foster quality improvement. Participants described their systems having different levels of achievement against the accreditation standards which they perceived fostered improvement, rather than being an indication of programme quality.

It's encouraged that accreditation agencies are transparent about why programs have not achieved full accreditation or lost their accreditation. (Participant D)

### Input versus outcome conflict

By articulating the core curriculum, staffing and resources required to receive accreditation, the standards were positioned to pledge the quality of the educational programme and its graduates. All standards were consistent in acknowledging that dietetic courses require a strong bioscience foundation instructed in an evidence-based paradigm. In addition, all standards continued to articulate that programmes should be overseen by a leader with specific credentials, such as a registered dietitian with doctorate qualifications. The standards varied across countries in how prescriptive they were in the core curriculum elements to be covered. This was a point of conflict, where some participants expressed that this could limit innovation as well as conflict with the principles of outcome-based education. Some countries, namely Canada and the United Kingdom through the HCPC standards, had shifted towards more outcome-focused standards, and this was perceived to be received positively by universities.

It was very 'tick boxy', very prescriptive. I didn't think that it acknowledged the people that put these training programs together: they are the innovators, they are the experts.... And so I put it to the board that we would move towards this outcome-based accreditation. (Participant C)

The conflict of input- versus outcome-based education was represented in the minimum number of placement hours to be completed by students. All dietetic accreditation standards continued to specify a minimum placement duration to be completed by graduates, with the exception of the HCPC standards. The HCPC accreditation standards did not stipulate placement duration requirements, instead suggesting universities be practice led and able to demonstrate how placement decisions support learning outcomes. The number of days or hours required by each country fluctuated, and many participants questioned the evidence supporting that a specific number of placement hours could assure graduate competency and safety. Despite the acknowledgement and criticism that this contradicted the principles of outcome-based education and that time on placement was not an exact way to measure achievement of competence, participants did not provide an alternative to input-based practicum requirements.

Provisions around placement standards, ... has probably been the most challenging. While the standards are really looking at ... outcomes of placement, the standard still has that ... days of placement required ... who is to say if you've done [a few less than that] you're not meeting the standard? (Participant B)

In the United States and Canada, universities were reported to be required by accreditation standards to set targets and evaluate graduate employment and employer satisfaction. The collection of such outcome data was reported to ensure that neither an under- or oversupply of dietetic graduates is created to meet the current and evolving needs of the population.

### DISCUSSION

Our study aimed to interpret the purpose and positioning of dietetics accreditation standards internationally, including the purpose espoused by accreditation standards, why this purpose is framed as it is and whether purpose differs internationally. Using participant interviews and key artefacts of accreditation standards, two key purposes of accreditation were identified internationally, including aiming to ensure safety and quality of graduates and provide support to universities. Input- versus outcome-based accreditation standards were identified as the one key conflict underpinning the meaning of accreditation. This study provides valuable insights into the purpose of dietetic education programme accreditation in addressing the current and emerging workforce needs as well as the conflicts that exist internationally. The findings also highlight the unified purpose of accreditation internationally, which may support global mobility of the dietetics workforce.

Public safety was perceived as the core underpinning purpose of accreditation, whereby compliance with accreditation standards acts to assure to the public that graduates are qualified to provide safe and effective care. This is consistent with other studies evaluating the purpose of accreditation within other health professions, which builds on the limited yet growing evidence that accreditation benefits the public by producing professionals who are better equipped for practice.<sup>1,11</sup> Because accreditation is recognised as serving a key function in creating high-calibre health professionals, participants recognised the logic in transitioning from input to graduate outcome metrics to assess programme effectiveness. The conflict between input- and outcome-based accreditation was prevalent throughout the analysis. Although input standards remained internationally (e.g., minimum number of placement hours, core curriculum, resources), interview participants recognised this was at

odds with the aims of outcome-based education and accreditation. Challenges in moving towards true competency-based education systems globally are not isolated to dietetics, with literature suggesting regulators must work together to effectively implement competency-based health professions education.<sup>12</sup> This study provides a step to advancing an international approach.

In addition to conflicting with the principles of outcome-based educational models, prescriptive standards were criticised as possessing the potential to limit educational innovation. The participants' perspectives are consistent with the existing literature, which calls for the education of health professionals to transition to outcome-based approaches as a more comprehensive assessment of graduate competence.<sup>1,13</sup> Supporting innovation may also encourage a move from quality assurance to a greater focus on quality improvement. Quality assurance processes have been found to be time consuming and highly prescriptive, with little evidence establishing its ability to better the quality of education and health services.<sup>14,15</sup> Measuring the degree to which an education programme engages in continuous quality improvement has been proposed as a method to meet the evolving needs of the health workforce.<sup>5,14</sup> Accreditation standards may need greater attention to standards and processes that foster review and improvement. Although the participants of this study perceived the process as fostering quality improvement, whether this perspective is shared by universities is unknown. All those involved in dietetics education must work together to advance education through leadership and embracing change.<sup>16</sup>

This fear of removing input-focused standards may reflect the profession's fear of unregulated practice as well as potential loss of professional identity. This was particularly evident in the United Kingdom, where the BDA curriculum framework continued to be input driven despite a shift by the HCPC's accreditation standards to become outcome focused. Input-based standards may be perceived as safeguarding the quality of a profession. This fear is largely unfounded, with other health professions moving away from input standards, for example, in physiotherapy.<sup>17</sup> A clearer understanding of a dietitian's professional identity may be useful in informing outcome-based approaches to curriculum design. There is limited evidence that describes dietitians' professional identity and of what exists is limited to personal characteristics<sup>18</sup> or allied health more broadly.<sup>19</sup> Recent evidence suggests that sociocultural factors in dietetics education may influence professional identity formation.<sup>20</sup> Moving away from prescriptive education may provide opportunities to advance the profession for the future – something that is being called for across the United States,<sup>21</sup> the United Kingdom,<sup>22</sup> Australia and New Zealand.<sup>23</sup>

This study was not without limitations, namely the exclusive inclusion of English-speaking countries with

similar models of dietetic programmes. Thus, this study may not be reflective of all dietetic accreditation processes globally. In addition, this study exclusively included accreditation services stakeholders and did not include universities' perspective of accreditation. However, this is the first study to compare dietetic accreditation standards internationally, and the results undoubtedly provide valuable insights into the different processes occurring internationally. Some countries may have moved towards new standards after this study and therefore may not be reflective of current quality improvement or outcome-based approaches. The data analysis undertaken by researchers less experienced in accreditation policy may have limited the depth of data interpretation.

## CONCLUSION

Identifying the consistent purpose and positioning of dietetic accreditation standards internationally, as ensuring safety to the public, quality of education and providing support to universities provides key data to potentially inform global mobility of the workforce. Managing the conflict that remains between input- versus outcome-focused accreditation standards will be a key challenge for accreditation agencies into the near future. The evolving nature of the dietetics workforce internationally has been identified, and accreditation policy may need to better support innovation to ensure dietitians are adequately equipped to meet future health and nutrition needs of the populations they serve.

## AUTHOR CONTRIBUTIONS

Claire Palermo and Sarah Meiklejohn conceptualised the study and collected the data. Lucie d'Udekem d'Acoz completed data collection and analysis and drafted the manuscript with feedback from Claire Palermo and Sarah Meiklejohn. All authors approved the final version of the manuscript.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## ETHICS STATEMENT

Monash University Human Research Ethics Approval number 23725.

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported.

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# Using an interactive nutrition technology platform to predict malnutrition risk

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## Abstract

**Background:** The Nutrition Dashboard is an interactive nutrition technology platform that displays food provision and intake data used to categorise the nutrition risk of hospitalised individuals. The present study aimed to investigate the Nutrition Dashboard's ability to identify malnutrition compared with a validated malnutrition screening tool (MST).

**Methods:** A retrospective observational study at a 99-bed hospital was conducted using medical record and food intake data presented via the Nutrition Dashboard. Inter-Rater Reliability of food intake estimation between hospital catering staff and a dietitian reported good agreement across 912 food items ( $\kappa = 0.69$ , 95% confidence interval = 0.65–0.72,  $p < 0.001$ ). Default nutritional adequacy thresholds of 4500 kJ and 50 g protein were applied for Nutrition Dashboard categorisation of supply and intake. Generalised estimating equation regression models explored the association between the Nutrition Dashboard risk categories and the MST, with and without controlling for patient demographic characteristics.

**Results:** Analyses from 216 individuals (1783 hospital-stay days) found that those in the highest risk Nutrition Dashboard category were 1.93 times more likely to have a MST score indicating risk compared to the lowest Nutrition Dashboard category (unadjusted odds ratio = 1.93, 95% confidence interval = 1.17–3.19,  $p < 0.01$ ). When patient weight was added to the model, lower weight became the only significant predictor of  $MST \geq 2$  ( $p < 0.01$ ).

**Conclusions:** The present study indicates a role for nutrition intake technology in malnutrition screening. Further adaptations that address the complexities of applying this technology could improve the use of the Nutrition Dashboard to support identification of malnutrition.

## KEYWORDS

energy intake, hospitals, informatics, malnutrition, technology

## Key points

1. Timely, accurate identification of malnutrition is essential in the acute care setting, but under-identification of malnutrition remains common despite best practice guidelines for malnutrition screening.
2. The present study identified that an interactive platform that displays food intake and nutrient data for hospitalised patients has potential to improve

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the identification of malnutrition when used in parallel with existing malnutrition screening.

3. The Nutrition Dashboard may improve the management of malnutrition by providing dietitians with malnutrition risk information directly rather than completely relying on the multi-disciplinary team to initiate screening and referrals.

## INTRODUCTION

Malnutrition is highly prevalent, burdensome and costly health issue that is under identified and therefore under managed especially in the acute healthcare setting. Malnutrition in hospitals results in significant negative health outcomes for individuals including increased length of stay (LOS), complications, and morbidity and mortality.<sup>1,2</sup> Global malnutrition screening using a validated tool, such as the Malnutrition Screening Tool (MST), can reliably identify malnutrition risk.<sup>2</sup> It is widely accepted that screening for malnutrition risk using a validated tool should be undertaken for all people admitted to hospital.<sup>3,4</sup> Despite best practice guidelines, policy review, ongoing research and education, routine malnutrition screening and identification remain inadequate.<sup>2,3,5</sup> A 2020 cross-sectional study across 45 Austrian hospitals over three years found that malnutrition screening was inadequate or not completed in 50.2% of the study population ( $n = 8405$  individuals).<sup>6</sup> In this study, 46.6% of people identified as at risk of malnutrition through screening were not referred to a dietitian.<sup>6</sup> Similar findings were reported in an Australian study published in 2012.<sup>7</sup> Best practice guidelines recommend that individuals identified at risk of malnutrition should be referred to a dietitian for assessment and diagnosis using a validated assessment tool such as the Subjective Global Assessment.<sup>2-4</sup>

The Nutrition Dashboard is an Australian novel nutrition technology platform developed by HealthShare New South Wales in collaboration with New South Wales Health Clinical Dietitians.<sup>8</sup> The Nutrition

Dashboard presents extensive meal ordering and intake data in an online platform. The data presented by the Nutrition Dashboard are collected by a trained hospital catering staff member using a validated electronic food intake tool (CBORD<sup>®</sup> Food and Nutrition Mobile Intake<sup>©</sup>)<sup>9,10</sup> at the end of each meal, and hospital catering staff estimate how much a patient has consumed from their meal tray for individual food items on a five-point visual scale with 25% increments or select 'not applicable' if they are unable to estimate (see Supporting information, Supplementary file S1, Figure S1). The Nutrition Dashboard uses the food ordering and intake data that is stored in CBORD food service software to categorise and present nutrition risk using adjustable threshold for energy and protein (Table 1).

The Nutrition Dashboard categorises nutrition risk using four categories. Category 1 is Low Supply – patients are receiving energy and/or protein below the threshold selected by the Nutrition Dashboard user. Category 2 is Low Intake – patients in category two are receiving energy and protein above the threshold, but their consumption of energy and protein is below the threshold. Category 3 is Possible Low Intake – patients in category three are receiving energy and protein above the threshold but their intake, as well as the energy and protein that has not been able to be visualised and estimated by catering staff, is below the threshold. Category 4 is classified as no issue noted – patients receiving and consuming energy and protein above the selected thresholds for energy and protein.

The Nutrition Dashboard provides insights into nutritional intake, which may relate to nutritional

**TABLE 1** Criteria for categorisation of nutrition risk as determined by the Nutrition Dashboard, using daily provided and consumed energy and protein data from CBORD Mobile Intake software

Nutrition dashboard category	Criteria
Category 1 – Definitive low supply	Daily provided energy and/or protein is less than threshold <sup>a</sup>
Category 2 – Definite low intake	Provided energy and protein is above threshold and consumed energy and/or protein is less than threshold <b>OR</b> Provided energy and protein is above threshold and consumed + unaccounted energy and/or protein is less than threshold
Category 3 – Possible low intake	IF not category 2 <b>AND</b> consumed daily energy and/or protein is less than threshold <b>AND</b> consumed daily average energy or protein + unaccounted energy or protein is greater than threshold
Category 4 – No issue noted	Receiving and consuming energy and/or protein more than threshold

<sup>a</sup>For this study thresholds were selected as 4500 kJ and 50 g protein which are the default thresholds presented by the Nutrition Dashboard.

status<sup>9,11</sup> (see Supporting information, Supplementary file S2, Figures S2 and S3). Traditionally, food intake is assessed in hospitals using patient recall or food intake records completed by healthcare staff. Given that these methods are prone to substantial error through inaccurate reporting, the use of technology may provide an alternative way to record and monitor food intakes.<sup>3,9,12,13</sup>

The use of technology in the healthcare setting is becoming increasingly commonplace. This growth in technology has occurred in many aspects of health care, including, but not limited to, electronic medical records, patient journey boards, biochemistry monitoring and support services such as food service. These technologies have large scale data sets with the potential to cultivate evidence and inform practice.<sup>14</sup> Research indicates that health professionals, including dietitians, routinely access data to complete daily tasks and are comfortable in doing so.<sup>14</sup> Australian research found that dietitians agree to strongly agree that they utilise data and technology to problem solve and to inform decision making.<sup>15</sup>

The assessment of food intake is a primary component of the assessment of malnutrition risk. There is increasing research regarding innovative technologies to assess food intake. Recent research indicates that novel diet assessment technologies, including the technology used to collect data which populates the Nutrition Dashboard can be valid at the individual level.<sup>11</sup> Research pertaining to the use of technology in the identification of malnutrition in hospitals is limited; however, preliminary studies indicate that the use of technology (including intake self-monitoring applications, electronic medical records and computerised malnutrition assessments) can assist in the identification and management of malnutrition.<sup>11,16,17</sup> Evidence surrounding nutrition intake monitoring tool technology (such as the Nutrition Dashboard) is particularly limited because of the need for hospital expenditure and infrastructure to implement them.<sup>16</sup>

The present study aimed to establish the accuracy of the Nutrition Dashboard in identifying clients with low dietary intakes (and therefore likely to be at risk or experiencing malnutrition) and to compare this to assessment with MST scores.

## METHODS

A retrospective observational study was completed in a 99-bed rural hospital utilising routinely collected data. An additional audit of written medical files included demographics, MST scores (on admission and weekly thereafter) and date of dietitian referral ( $n = 309$ ). A final year trainee dietitian completed MST scores for all admitted patients for the study period (June to August 2020) to ensure availability and reliability. Patient file data was accessed for individuals admitted to hospital for  $\geq 3$  days, aged 18 years and over who were based on medical, surgical or high

dependency wards. Patients receiving end of life care or enteral or parenteral nutrition were excluded.

An assessment of the inter-rater reliability (IRR) of the Nutrition Dashboard data collection process was undertaken prior to the audit. The IRR assessment involved the dietitian researcher (E.F.) visually estimating and recording the amount consumed or selecting 'not applicable' (NA) for each individual food item for a total of 119 meals and 912 individual food items in 25% increments. These estimates were then compared with food service staff estimations. Fleiss' kappa was used to measure inter-rater agreement on a nominal scale (separate categories that included 0%, 25%, 50%, 75%, 100% consumption and NA) for all 912 ratings and found good agreement ( $\kappa = 0.69$ , 95% confidence interval (CI) = 0.65–0.72,  $p < 0.001$ ). Low nutritional value (i.e.,  $< 41$  kJ per item) items were then removed, this resulted in analysis of 591 individual food items and higher agreement ( $\kappa = 0.77$ , 95% CI = 0.72–0.82,  $p < 0.001$ ).

Food intake and consumption data were extracted for each day of a patient's admission period, across the study timeframe, including daily provided and consumed energy and protein, as well as unaccounted intake data, for each patient. Unaccounted intake data is reported by the trained food service catering staff using the electronic software. Unaccounted data may be attributed to a patient keeping a food item for later or disposing of it before the meal tray is collected by the food service staff. Provided and consumed energy and protein data was extracted from hospital food service software (CBORD) for individual food items for every meal. Aggregates of provided and consumed energy and protein were created for daily energy and protein provision and consumption. The Nutrition Dashboard only presents information for patients admitted to hospital and receiving meals for  $\geq 3$  days. For analysis, only medical files that included  $\geq 3$  days of Nutrition Dashboard data were included as per Nutrition Dashboard process. The daily Nutrition Dashboard category for energy and then protein was calculated for each individual admission using the standard Nutrition Dashboard process (Table 1) by the dietitian researcher (E.F.) and biostatistician (G.L.).

When a clinician accesses the Nutrition Dashboard, default threshold values presented for nutrition risk categorisation are 4500 kJ for energy and 50 g of protein per day. The global estimation of energy and protein requirements for a diverse hospitalised population is complex.<sup>18</sup> The Agency for Clinical Innovation Nutrition Standards and Diet Specifications (2011) recommend 8000 kJ and 90 g protein day<sup>-1</sup> as the goal for provision of adequate nutrition for adults admitted to hospital.<sup>19</sup> Guidelines from the American Society for Parenteral and Enteral Nutrition (ASPEN) and National Institute for Health and Care Excellence (NICE) estimate 85–125 kJ kg<sup>-1</sup> day<sup>-1</sup> and 1–1.5 g protein<sup>-1</sup> kg<sup>-1</sup> day<sup>-1</sup> as adequate for hospitalised adults.<sup>20,21</sup> It is common for patients admitted to hospital to consume inadequate nutrition.<sup>22</sup>

A 2017 study in the UK found that more than 75% of both nutritionally well and nutritionally vulnerable adult population consumed sub-optimal energy and protein intakes from hospital provided diets.<sup>22</sup> A significant or prolonged deficit in energy and or protein intake is associated with an increased risk of malnutrition. For the purposes of analysis in the present study, the energy thresholds were maintained at the default values of 4500 kJ and 50 g for protein. These thresholds align with a 30%–45% deficit intake for estimated energy and protein requirements according to the Australian guidelines for adult hospital diets and the ASPEN and NICE guidelines.<sup>19–21</sup> As per Nutrition Dashboard process (Table 1), the most severe daily risk category out of energy and protein was selected for each patient, for each day of admission.

Weekly weight and MST measures were matched to daily Nutrition Dashboard category for each individual file. Only files with a MST score on admission were included in data analysis. For those with admissions >1 week, where a weekly MST score was missing, that week of data was excluded from analysis.

Descriptive statistics were undertaken to explore the demographic profile and admission characteristics of the study group. The mean  $\pm$  SD was calculated for continuous data (weight). Data that were not normally distributed were presented as median and interquartile range (IQR) (age and LOS).

MST score was dichotomised as low risk of malnutrition (MST < 2) and increased risk ( $\geq 2$ ) for analysis as per recommended interpretation.<sup>23</sup> A regression model was applied to determine whether the Nutrition Dashboard category (1–4) is a good predictor of MST score. Generalised estimating equation (GEE) regressions were used to model the relationship between dichotomised MST score and Nutrition Dashboard Category to account for potential correlations between repeated longitudinal measurements. The GEE was used to investigate the hypothesis that the Nutrition Dashboard has the ability to predict increased risk of malnutrition (as measured by MST  $\geq 2$ ). Further modelling was developed including age, gender, LOS and weekly weight (including weight on admission) as additional variables. The modelling developed by the GEE was presented as unadjusted odds ratio (OR) with a 95% CI. All analyses were conducted using appropriate statistical software (SPSS, version 25; IBM Corp.).  $p < 0.05$  was considered statistically significant.

Ethical approval for this study was obtained from Hunter New England Research Ethics Committee 18/12/2019 (ETH13100).

## RESULTS

In total, 216 individual patient files (written medical files with matched Nutrition Dashboard data) were included in the study for a total of 237 admissions and 1783

**TABLE 2** Patient characteristics in a study investigating the use of the Nutrition Dashboard to identify malnutrition

Patient characteristics	Descriptive statistics
Age on admission (years)	
Median (IQR)	74 (23)
Minimum–maximum	18–104
Gender	
Male, <i>n</i> (%)	123 (56.9)
Length of stay (days)	
Median (IQR)	6 (5)
Minimum–Maximum	3–58
Weight on admission (kg) ( <i>n</i> = 181)	
Mean (SD)	80.8 (22.7)
Minimum–maximum	36.7–163.4
MST score $\geq 2$ , <i>n/N</i> <sup>a</sup> (%)	140/363 (38.6)

Abbreviations: IQR, interquartile range; MST, Malnutrition Screening Tool.

<sup>a</sup>MST  $\geq 2$  proportion is based on the number of MSTs collected for 216 patients across a total of 298 weeks of admissions.

**TABLE 3** Distribution of malnutrition screening tool scores with nutrition dashboard categories (*n* = 216 patients)

Nutrition dashboard category	MST 0–1, <i>n</i> (%)	MST $\geq 2$ , <i>n</i> (%)
Category 1 – Definitive low supply	121 (6.8)	116 (6.5)
Category 2 – Definite low intake	106 (6)	78 (4.4)
Category 3 – Possible low intake	148 (8.3)	118 (6.6)
Category 4 – No issue noted	727 (41)	361 (20)

Abbreviation: MST, Malnutrition Screening Tool.

hospital-stay days, after files for missing or incomplete data were excluded. Of the 216 files included in the study, 56.9% were from males and the median LOS was 6 days (IQR = 5). Thirty-nine percent (*n* = 140/363) of weekly MST scores calculated from files included in the study were categorised as ‘at risk’ of malnutrition (Table 2).

Weekly malnutrition risk as measured through MST (risk  $\geq 2$  and low risk 0–1) was correlated with the daily Nutrition Dashboard categories 1 to 4 ( $X^2 = 28.8$ ,  $df = 3$ ,  $p < 0.01$ ). A low-risk MST (0–1) was more likely to be a low risk Nutrition Dashboard category (category 4) rather than a higher risk MST ( $\geq 2$ ) (Table 3).

A model developed using the GEE to compare MST to Nutrition Dashboard categories was statistically significant (Wald  $X^2 = 10.89$ ,  $df = 3$ ,  $p < 0.05$ ). The model showed that Nutrition Dashboard categories 1 (OR = 1.93, 95% CI = 1.17–3.19) and 3 (OR = 1.61, 95% CI = 1.12–2.30) were significant predictors of a MST  $\geq 2$  ( $p < 0.01$  for both) but not category 2 ( $p = 0.059$ ) when

TABLE 4 Multivariable generalised estimating equation model: association between MST  $\geq 2$  and Nutrition Dashboard category ( $n = 216$  patients)

Nutrition dashboard category	Unadjusted OR	95% CI	<i>p</i> value
Category 1 – Definitive low supply	1.93	1.17–3.19	0.010*
Category 2 – Definite low intake	1.48	0.99–2.23	0.059
Category 3 – Possible low intake	1.61	1.12–2.30	0.010*
Category 4 – No issue noted	Reference category	NA	NA

Abbreviations: CI, confidence interval; OR odds ratio; MST, Malnutrition Screening Tool; NA, not applicable.

\* $p < 0.05$ .

TABLE 5 Multivariable generalised estimating equation model: association between MST  $\geq 2$ , Nutrition Dashboard Category and possible confounders ( $n = 216$  patients)

Nutrition dashboard category	Adjusted OR	95% CI	<i>p</i> value
Category 1 – Definitive low supply	1.89	1.15–3.11	0.012*
Category 2 – Definite low intake	1.43	0.97–2.11	0.074
Category 3 – Possible low intake	1.63	1.13–2.34	0.009**
Category 4 – No issue noted	Reference category	NA	NA
Sex, female	1.01	0.54–1.89	0.977
Age (years)	1.01	0.99–1.03	0.448
Length of stay	0.997	0.97–1.02	0.809

Abbreviations: CI, confidence interval; OR odds ratio; MST, Malnutrition Screening Tool; NA, not applicable.

\* $p < 0.05$ ; \*\* $p < 0.01$ .

compared with Nutrition Dashboard Category 4 (Table 4).

A GEE model that included gender, age and LOS as possible confounders revealed that the Nutrition Dashboard categories 1 and 3 remained the only significant predictors of MST  $\geq 2$  (Wald  $X^2 = 10.78$ ,  $df = 3$ ,  $p < 0.05$ ) (Table 5).

The median weight for those with an ‘at risk’ (MST  $\geq 2$ ) was 73 kg (IQR = 28.1; range 41.8–151 kg) and for those ‘not at risk’ (MST 0–1) was 84 kg (IQR = 24.0; range 36.4–163.4 kg). Weight was included as a potential confounder for the above analyses. There were 185 patients with complete data for analysis. When weight was included in the GEE model alongside Nutrition Dashboard Category, age, gender, and LOS, a lower weight became the only significant predictor of MST  $\geq 2$  ( $p < 0.01$ ) (Table 6).

During the study period, 95 admissions (38.6%) had at least one MST score  $\geq 2$ , and 140 MST scores were  $\geq 2$  across 363 repeated measures (MST score on admission and weekly thereafter). Forty-three out of the 87 individuals

TABLE 6 Multivariable generalised estimating equation model: association between MST  $\geq 2$ , Nutrition Dashboard Category and possible confounders including weight ( $n = 185$  patients)

Nutrition dashboard category	Adjusted OR	95% CI	<i>p</i> value
Category 1 – Definitive low supply	1.78	0.98–3.22	0.057
Category 2 – Definite low intake	1.53	0.91–2.58	0.110
Category 3 – Possible low intake	1.35	0.86–2.13	0.189
Category 4 – No issue noted	Reference category		
Sex, female	0.77	0.36–1.62	0.488
Age (years)	1.01	0.99–1.03	0.318
Length of stay	0.98	0.96–1.01	0.223
Weight	0.97	0.96–0.99	0.006*

Abbreviations: CI, confidence interval; OR odds ratio; MST, Malnutrition Screening Tool; NA, not applicable.

\* $p < 0.01$ .

(45.3%) identified in medical records as being ‘at risk’ of malnutrition were referred to a dietitian.

## DISCUSSION

To our knowledge, the present study is the first to report on the use of the Nutrition Dashboard for identifying malnutrition risk. The study indicates potential for use of this platform to identify those that may be at increased risk of malnutrition for subsequent assessment and management. Almost 40% of the study sample had a MST score of at least 2, indicating increased risk of malnutrition, which is consistent with published prevalence of malnutrition in the hospital setting.<sup>1,24,25</sup> As predicted, the Nutrition Dashboard category for lowest intake (category 1) was the most likely to predict an increased risk of malnutrition when compared with category 4 (no issue noted) (OR = 1.93,  $p < 0.05$ ). The finding that Nutrition Dashboard category 1 (definitive



low supply) and 3 (possible low intake) were modest but statistically significant predictors of a MST  $\geq 2$  compared to category 4 were consistent with the study hypothesis. The absence of a statistically significant association between category 2 (definite low intake) and a MST  $\geq 2$  may have related to the smaller sample size (4.4% of the total population) in this category, with less power to detect a difference between measures.

This study found that Nutrition Dashboard category 3 (possible low intake) was a modest but statistically significant predictor of increased risk of malnutrition when compared with Nutrition Dashboard category 4 (no issue noted), despite including individuals who had unaccounted food intake data. These findings suggest that the nutrition dashboard maintains some value in predicting risk of malnutrition, even for individuals with unaccounted food intake data. Increasing age and LOS have been found to be associated with an increased risk of malnutrition<sup>1,5,26</sup>; however this study found that Nutrition Dashboard categories 1 (definitive low supply) and 3 (possible low intake) were better predictors of malnutrition than age and LOS. As a static measure, a higher weight also modestly predicted lower risk of malnutrition risk. Although malnutrition is not exclusive to those with a low body weight, those with lower body weight are at increased risk of malnutrition, especially in the acute care setting.<sup>27–29</sup>

Identifying and managing malnutrition is a time sensitive issue, with missed or delayed referrals to a dietitian resulting in poorer health outcomes.<sup>11,24</sup> A multi-disciplinary approach is important for optimal identification and management of malnutrition. Research indicates that screening and referral of patients at risk of malnutrition is not adequate in many hospitals.<sup>1,3,6</sup> Ancillary and nursing staff are often responsible for the multi-step malnutrition screening and referral process, but are time poor and have multiple, conflicting commitments.<sup>5,27,30</sup> This study suggests that the Nutrition Dashboard could be used in parallel to existing MST screening by providing dietitians with the nutrition risk information directly to improve the timely identification of likely malnutrition.

European, US and Australian best practice guidelines all recommend nutrition risk screening using a validated tool and subsequent referral to a dietitian for those identified at risk for all hospital patients.<sup>4,31,32</sup> The dietitian referral rate of 45% for those 'at risk' of malnutrition is consistent with an international 45-hospital study involving 8405 patients reporting that 37% of people at risk of malnutrition were referred to a dietitian,<sup>6</sup> as well as an Australian study reporting that 45% of individuals at risk of malnutrition were being managed by a dietitian.<sup>7</sup> Together, these findings indicate that best practice standards for management of malnutrition are not being achieved.<sup>31</sup> In Australia, diagnosis and documentation of pre-existing malnutrition in the medical file attracts additional activity-based funding for

hospitals.<sup>24</sup> This is a result of the increased cost and complications associated with the diagnosis of malnutrition. In Australia, dietitians have primary responsibility for the diagnosis of malnutrition, and poor screening and referral of patients at risk of malnutrition results in a substantial shortfall in funding for acute care settings, as well as poor nutrition care and outcomes.<sup>24</sup>

There is no published literature comparing the Nutrition Dashboard with traditional methods of recording and monitoring patients' dietary intake. Previously, dietitians have relied on patient recall or food intake charts to monitor and evaluate the nutritional adequacy of an individual's diet during admission to hospital.<sup>9,13</sup> Both approaches have substantial limitations, with research indicating that up to 97% of food charts are incomplete and inaccurate.<sup>13</sup> Alternately, the Nutrition Dashboard monitors patient's food intake, as estimated by trained food service staff. With further research, it is expected that the additional analytic capacity of the Nutrition Dashboard could improve malnutrition management by providing dietitians with accurate, timely nutrition data. The findings of this research suggest that the Nutrition Dashboard can provide meaningful food intake information directly to dietitians, thus reducing the responsibility of other time poor health professionals, particularly nursing staff.

Optimising the management of malnutrition risk in hospital settings is essential because malnutrition results in poorer health outcomes and higher healthcare costs. However, it is important to acknowledge the potential impact on hospital systems. Health professionals face increasing workloads that may not be supported by proportionate increases in funding, especially in rural clinical practice.<sup>33</sup> The findings of the present study indicate that adequate referral of those identified at possible risk of malnutrition would result in more than double the number of referrals for malnutrition risk to a dietitian. Refinement and implementation of innovative models of malnutrition risk screening, referral and care have the potential to drive change towards more judicious care planning and dietetic referral pathways.

The strengths of the present study includes the use of a retrospectively collected comprehensive data set in a setting where the processes underpinning the Nutrition Dashboard have been embedded for more than 18 months. The high MST data completion rate was achieved because it was collected by a trainee dietitian for the audit period. The limitations of the study included investigation of only one default threshold for protein and energy for nutrition risk categorisation. Future research is proposed to investigate multiple thresholds including estimated dietary requirements for patients included in the study. The Nutrition Dashboard currently presents data for patients admitted for  $\geq 3$  days or more; ideally, the Nutrition Dashboard would present data for all admissions in acknowledgement of the importance of nutrition risk screening on admission.



Additionally, the data were collected across June to August 2020 during the COVID-19 pandemic when elective surgeries were not being performed and presentations to hospital were lower than average, which may have impacted on the characteristics of the usual population of an acute care setting

The relationship between nutrition risk identified by the Nutrition Dashboard and increased risk of malnutrition as measured by a validated screening tool identified in the present study demonstrates the potential application of the Nutrition Dashboard to identification and management of malnutrition. Nutrition Dashboard category alone was not a strong predictor of an at-risk MST score and weight status impacted on the Nutrition Dashboards ability to predict malnutrition. There is scope to investigate and account for these factors with large scale testing and refinement of the model using data from multiple health facilities. The Nutrition Dashboard is not intended as a sole malnutrition screening method, but system refinement and validation against Subjective Global Assessment scores could make it suitable to incorporate into care planning and dietetic referral pathways.

The Nutrition Dashboard presents detailed nutrition intake data that has been shown to be associated with nutrition risk directly to dietitians, and this research confirms that it has the potential to play a role in improving nutrition care.

#### AUTHOR CONTRIBUTIONS

*Research question and protocol design:* Erin Fisher with contributions from Kerith Duncanson, Georgina Luscombe, David Schmidt and Leanne Brown. *Planning discussions for data analysis:* David Schmidt. *Statistical analysis:* Georgina Luscombe. Manuscript authored by Erin Fisher with review from Kerith Duncanson, Georgina Luscombe, Leanne Brown and David Schmidt.

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#### CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

#### TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important aspects of the study have been omitted and

that any discrepancies from the study as planned have been explained.

#### PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1111/jhn.13088>.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# A Mediterranean and low-fat dietary intervention in non-alcoholic fatty liver disease patients: Exploring participant experience and perceptions about dietary change

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## Abstract

**Background:** A Mediterranean diet (MD) appears to be beneficial in non-alcoholic fatty liver disease (NAFLD) patients in Mediterranean countries; however, the acceptability of a MD in non-Mediterranean populations has not been thoroughly explored. The present study aimed to explore the acceptability through understanding the barriers and enablers of the MD and low-fat diet (LFD) interventions as perceived by participating Australian adults from multicultural backgrounds with NAFLD.

**Methods:** Semi-structured telephone interviews were performed with 23 NAFLD trial participants at the end of a 12-week dietary intervention in a multicentre, parallel, randomised clinical trial. Data were analysed using thematic analysis.

**Results:** Participants reported that they enjoyed taking part in the MD and LFD interventions and perceived that they had positive health benefits from their participation. Compared with the LFD, the MD group placed greater emphasis on enjoyment and intention to maintain dietary changes. Novelty, convenience and the ability to swap food/meals were key enablers for the successful implementation for both of the dietary interventions. Flavour and enjoyment of food, expressed more prominently by MD intervention participants, were fundamental components of the diets with regard to reported adherence and intention to maintain dietary change.

**Conclusions:** Participants randomised to the MD reported greater acceptability of the diet than those randomised to the LFD, predominantly related to perceived novelty and palatability of the diet.

## KEYWORDS

Australia, diet, low fat diet, Mediterranean diet, non-alcoholic fatty liver disease, perception

## Research highlights

- Participants enjoyed taking part in the Mediterranean diet (MD) and low fat diet (LFD) interventions and perceived that they had positive health benefits from their participation.

- Participants randomised to the MD reported greater acceptability of the diet than those randomised to the LFD, predominantly related to perceived novelty and palatability of the diet.
- Compared with the LFD, the MD group placed greater emphasis on enjoyment and intention to maintain dietary changes.
- Novelty, convenience and the ability to swap food/meals were key enablers for the successful implementation for both of the dietary interventions.
- Flavour and enjoyment of food, expressed more prominently by MD intervention participants, were fundamental components of the diets with regard to reported adherence and intention to maintain dietary change.

## INTRODUCTION

There has been extensive research surrounding the Mediterranean diet (MD) for the prevention and management of chronic diseases,<sup>1</sup> which has led to an increase in its popularity, including in non-Mediterranean countries such as Australia. However, the MD has not been studied in large scale clinical trials for the management of chronic diseases outside the Mediterranean region. The Mediterranean Dietary Intervention for Patients with Non-Alcoholic Fatty Liver Disease (MEDINA) trial is a 12 week, multicentre, parallel, randomised controlled trial comparing effects of a Mediterranean diet (MD) and a low-fat diet (LFD) on insulin resistance and hepatic steatosis in participants with non-alcoholic fatty liver disease (NAFLD).<sup>2</sup> The protocol and treatment effects for the MEDINA primary outcomes are reported elsewhere.<sup>2,3</sup> In the present study, we sought to understand how the respective prescribed diets and their components are perceived by a multicultural cohort where the LFD is likely more familiar given it is supported by national dietary guidelines and those of affiliated organisations (The Heart Foundation) and where the constituents of a MD are not so familiar and/or habitually consumed by the population. A LFD is currently promoted by health professionals and a MD is currently recommended for chronic disease management and NAFLD in European guidelines. Therefore, investigation of whether the MD and specific elements of the MD are acceptable and thus can be further explored in clinical trials as an acceptable dietary management strategy for chronic disease management, which has potential to be scaled up for implementation within a multicultural Australian cohort, is warranted. With regard to the MD, these findings may assist with the translation of the diet for other non-Mediterranean populations where chronic disease management through application of a MD may be indicated and where barriers have been identified for its implementation.<sup>4</sup>

The present study aimed to assess the acceptance of both the MD and LFD in a multicultural Australian population and to evaluate whether the MEDINA clinical trial achieved participant engagement and dietary

behaviour change, as well as explore participants' perceptions of specific dietary components of the MD and LFD. The study will report on key factors that enable and hinder application of the two dietary interventions in a multi-ethnic Australian population with NAFLD, which can be considered when tailoring future interventions to maximise adherence.

## METHODS

### The MEDINA trial

The dietary intervention comprised three face to face consultations with an Accredited Practising Dietitian (APD) at weeks 0, 6 and 12 and three phone call reviews at weeks 2, 4 and 9. The MEDINA trial protocol and description of the diet are published elsewhere.<sup>2</sup> The dietary prescription was comprehensively designed and the details have been published elsewhere.<sup>5</sup> In brief, the diet was designed to be easy to follow and sustainable with an *ad libitum* approach focusing on positive coaching, emphasising foods encouraged for consumption rather than foods to avoid. All dietary consultations were administered to participants by an APD who was able to tailor the diet to cultural and personal preferences through recommendation of nutritionally appropriate suggestions and alternatives. The APDs administering the MD were independent from the LFD APDs to avoid any bias or contamination between study arms. All participants assigned to the MD were provided with written resources designed to support implementation of the diet and a hamper containing staple ingredients including extra virgin olive oil, nuts, legumes and oily fish. The LFD, representing mainstay recommendations, was the study 'control', with the number of appointments matched to adjust for intervention intensity and contact with a dietitian. The LFD group were provided with nutrition education and resources as determined by the APD running the consultations to replicate a typical outpatient dietetic consult. Participants in the LFD group were given a supermarket gift voucher to purchase some of the suggested food items.



## Interviews

At the completion of the intervention, participants randomised to both the MD and LFD intervention groups were invited to participate in semi-structured interviews to investigate whether whole diet(s) were acceptable to participants and whether there were individual components of the diets that were deemed/perceived as more acceptable than others. The interview questions were developed by the research team with consideration of the potential determinants of success in the application of a dietary intervention. The interview questions are included in Table 1. The interview was divided into two key parts.

Part one of the interview was designed to evaluate the interventions through exploring participant perceptions of the overall trial experience and satisfaction associated with taking part in the MEDINA study. Data were collected to determine whether the appointment schedule and intervention design and delivery were executed in a manner that promoted attendance and participation in the respective dietary interventions, and whether participants perceived their involvement to be beneficial to their health or otherwise.

Part two of the interview explored participant acceptability of each of the interventions including key dietary recommendations. These data explore participants' views and experiences regarding specific aspects of the diet prescribed, as well as their desire and perceived ability to maintain dietary changes. Specific strategies employed by individual participants to implement each dietary change were also explored.

## Participants and sampling

All participants who were enrolled and completed the trial in the overarching MEDINA RCT at the time that this sub-study was conducted (January 2015 to December 2016; 23 participants) were invited to take part in semi-structured interviews.

## The interview structure

Interviews were held within 6 weeks of completing the MEDINA trial. The semi-structured interview was administered by a researcher not involved in the dietary counselling to minimise response bias by participants. Interviews were conducted via telephone to minimise participant burden and increase participation. The interview was field-tested with two researchers and then with the first participant recruited and modifications were made iteratively to the interview questions to improve clarity and face validity. Participants were provided with questions in advance to promote considered responses. During the interviews, participants were invited to share their experiences and perceptions

TABLE 1 Semi-structured interview schedule of questions

Sections	Questions																		
Part 1	<ol style="list-style-type: none"> <li>1. Why did you decide to participate in the program?</li> <li>2. Was the program what you expected?</li> <li>3. Did you miss any appointments? If so, why?</li> <li>4. Were there enough appointments? Were the appointments too close together or too far apart? Did you find it difficult to attend your appointments?</li> <li>5. How easy was the diet to follow? Did you find the advice provided easy to follow? What was easy or difficult about the diet?</li> <li>6. How did you feel about setting goals during the program?</li> <li>7. Did you enjoy the diet? Why or why not? What aspects of the diet did you enjoy most?</li> <li>8. What did you find was challenging to change about your diet? Were there any particularly difficult parts that you found hard to include in your diet? Why?</li> <li>9. Did you feel satisfied while following the diet? (Satiety, were you ever hungry or felt deprived?)</li> <li>10. Did you find the written resources useful? Which handouts did you like the best/least?</li> <li>11. Did you achieve the results you hoped for OR Do you feel that you benefited from participation in this program. How/Describe.</li> <li>12. Do you feel you have/will continue with the changes made?</li> <li>13. How could we improve the program?</li> <li>14. Did you enjoy receiving a food hamper/voucher? Did you use everything in the hamper/what did you use this to purchase? Why/Why not?</li> <li>15. If you had the choice, would you see a dietitian again? Why/Why not?</li> <li>16. Is there anything else that you would like to comment on?</li> </ol>																		
Part 2	<p><i>Questions asked for each diet specific category were:</i></p> <ol style="list-style-type: none"> <li>i. Did you increase the amount consumed?</li> <li>ii. Have you or do you think you will maintain this change?</li> <li>iii. Have you enjoyed this change?</li> <li>iv. How have included this in your diet/what strategies of including this have you enjoyed?</li> </ol> <table border="0"> <thead> <tr> <th>For the <b>Mediterranean Diet</b> group the following diet specific foods were asked about:</th> <th>For the <b>Low Fat Diet</b> group the following diet specific foods/categories were asked about:</th> </tr> </thead> <tbody> <tr> <td>1. Extra virgin olive oil</td> <td>1. Reduced fat items (dairy, trimmed meat and added fats).</td> </tr> <tr> <td>2. Nuts</td> <td>2. Vegetables</td> </tr> <tr> <td>3. Vegetables</td> <td>3. Fruit</td> </tr> <tr> <td>4. Fruits</td> <td>4. Low fat cooking methods</td> </tr> <tr> <td>5. Legumes</td> <td>5. Wholegrains</td> </tr> <tr> <td>6. Fish</td> <td>6. Portions</td> </tr> <tr> <td>7. Meat (reducing)</td> <td></td> </tr> <tr> <td>8. Wholegrains</td> <td></td> </tr> </tbody> </table>	For the <b>Mediterranean Diet</b> group the following diet specific foods were asked about:	For the <b>Low Fat Diet</b> group the following diet specific foods/categories were asked about:	1. Extra virgin olive oil	1. Reduced fat items (dairy, trimmed meat and added fats).	2. Nuts	2. Vegetables	3. Vegetables	3. Fruit	4. Fruits	4. Low fat cooking methods	5. Legumes	5. Wholegrains	6. Fish	6. Portions	7. Meat (reducing)		8. Wholegrains	
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without a rigid adherence to the scripted questions. Each interview lasted about 20 min. Interviews were de-identified and then transcribed by a researcher and cross checked by a second researcher.



Ethics approval was obtained within the application for the overarching MEDINA trial and parameters of this qualitative study were included in the primary ethics approval through the participating hospitals, Alfred Health, Royal Melbourne and Eastern Hospitals and La Trobe University, Melbourne, Victoria, Australia. All participants provided informed consent. There were no additional incentives provided for participation in this aspect of the trial.

## Data analysis

For part one, an approach using the principles of content analysis was employed through interpretation and coding of textual responses using a systematic evaluation. Content analysis specifically allows the quantification of qualitative data with caution as a proxy for significance.<sup>6</sup> The participant responses were collated, coded and summarised with key themes conveyed under distinct sub-headings that emerged from participant responses and were related to the overall structure of the dietary intervention.<sup>7,8</sup>

For part two, thematic analysis was used to manually code responses to the open-ended described by Braun and Clarke.<sup>9</sup> Each stage was carried out until no new themes were identified. Handwritten responses from researchers who conducted the interview were transcribed to electronic records. The data was then read and reviewed line by line and each discrete idea or concept was noted. Then, initial themes were noted and grouped. This involved reading the participant responses and looking for patterns of meaning and issues of potential interest within the data. This was conducted by one researcher and cross checked independently by a second. These themes were then further reviewed to check if they fit with initial concepts and with the entire data set. Then, themes were defined and refined. Examples and extracts were selected and reviewed to ensure that there was a clear description of themes before reporting the results.

## RESULTS

### Demographics

There were 25 participants recruited and randomised to either the MD or LFD arm of the overarching MEDINA trial at the time this research was conducted. Of these, two participants withdrew for family or medical reasons. Of the 23 participants who completed the intervention, all agreed to take part in the interviews. There were 12 participants in the LFD arm (six males) and 11 participants in the MD arm (five males). Main outcomes and dietary compliance are reported elsewhere but, briefly, the MEDAS score used to assess adherence to the MedDiet and the equivalent score for the LFD were applied to each group's respective

food diaries. Compliance with the MedDiet improved by 2.7 units (mean  $\pm$  SD) ( $6.5 \pm 2.0$  to  $9.2 \pm 1.9$ , out of a maximum possible score of 14) ( $p < .0005$ ). In the LFD group, compliance with the prescribed diet improved by 1.0 unit ( $5.4 \pm 2.0$  to  $6.4 \pm 2.3$ , out of a maximum possible score of 9) ( $p = .035$ ).<sup>3</sup>

The mean  $\pm$  SD age for the overall group was  $49.6 \pm 15.9$  years (range 21–73 years). Most participants recruited (68%) were born in countries other than Australia. Participants self-reported ethnicity as 44% Asian, 32% European, 16% Oceanian and 8% Middle Eastern.

### Part one: Participant satisfaction

Participants reported that they were satisfied with the number and frequency of appointments. Many characteristic themes also emerged with a focus on barriers and enablers related to the delivery and uptake of the dietary interventions. Sub-themes and associated quotes are presented in Table 2.

### Motivations

Weight loss, recommended participation from their specialist or fear of disease progression were the most frequently cited motivations for participation.

### Perceptions on dietary prescription

The barriers highlighted by participants were predominantly related to their personal lives and fitting the prescribed diet into their schedule.

For the LFD group, there was a strong focus on restriction of foods being a barrier despite a reduction in energy not being a focus of the dietary prescription. Long-term maintenance of dietary changes was also perceived as a barrier. Only a minority of LFD participants indicated that the diet was not challenging and that the recommendations were familiar.

A minority of participants recounted feeling hungry; in both the MD and LFD groups, this was attributed to skipped meals or snacks. Accountability, simplicity of goals and contact with a dietitian were seen as key enablers for participants. Most participants reported that the food diary aided adherence through accountability.

### Dietary intervention delivery techniques

Participants in the MD group reported that the diet was easy to follow and the resources, hamper, recipe book and some elements of the diet were specifically mentioned as making the diet easier to follow. The LFD group indicated they were happy with the supermarket

TABLE 2 Participant satisfaction: perceptions from part one of the semi-structured interview

Participant satisfaction categories	Themes	Examples of quotes from semi-structured interviews
Motivations	Weight loss	[I] need to lose weight (MD participant) [I] have always battled with weight loss (LFD participant)
Perceptions of dietary prescription	Time management	[I was] working full time and family made it difficult to concentrate on the diet but [I] really liked [the diet] (MD participant)
	Restriction	Breaking bad habits like eating sugary snacks after dinner and cutting out rice 'carbs' and potato chips was very hard- and not replacing (LFD participant)
	Satiety	[I] felt satisfied with the right amount of snacks like nuts and oats, [I] felt full and never hungry (MD participant) [I was] not 'deprived' unless [I] missed a meal, then [I] felt hungry (LFD participant)
	Psychological adjustment	[I] felt like [I] wasn't having enough, but [I] didn't feel lack of energy, just psychological 'need' for food (LFD participant)
Dietary intervention delivery techniques	Goal setting	Setting goals made [me] more conscious of what [I] was eating and drinking, a beneficial task' and; 'It was easy to set goals but keeping them was not so easy but seeing the dietitian frequently helped to keep up with goals (MD participant)
	Resource provision	[I] found the diet [could] be translated easily into [my] lifestyle and [I have] not enjoyed a low fat diet in the past and: initially [I] found it pretty easy, [the] recipe book and pamphlets made it easier (MD participant) The resources were fantastic, [I] loved the Med Diet cookbook, the recipes didn't deny [me] good food (MD participant)
	Dietary prescription	[I] would have preferred an actual diet plan, weekly, instead of the broader information that [I] was given (LFD participant)
Perceived benefits and sustainability	Improvements in health	Initially [my] goal was to lose weight, but [I] didn't actually lose too much, however [I] just went to the liver clinic recently and they noticed the changes in my liver function so [I] will keep to the diet given the outcomes (MD participant) [My] weight stayed the same but I felt better mentally and physically (MD participant)
	Weight loss	[I] don't think I got any benefit because [I] lost no weight and [my] fat mass increased (LFD participant)
	Maintenance	[I] will definitely continue the changes but probably not as strict as when [I] was on the study, but [I] will keep the main principles and strategies [I] learnt and: [I] have reverted back to some bad habits but [I am] trying to go back to the principles of the Med Diet (MD participant) Yes [I] will continue to decrease my sugar intake and eat more vegetables and fruit (LFD participant)

Abbreviations: LFD, low fat diet; MD, Mediterranean diet.

vouchers (which were supplied in place of the hamper and cookbook); participants reported that they used them predominantly to purchase fruit and vegetables.

## Perceived benefits and sustainability

All participants indicated that they wanted to continue with the dietary changes made and the MD group in particular expressed that they were confident in their ability to maintain the diet. Interestingly, many

participants reflected that, even without weight loss, they felt better or noticed improvements in their health outcomes at follow up medical appointments.

## Part two: Participant perceptions of dietary components

The second part of the semi-structured interview included a range of questions pertaining to the acceptability of the key dietary recommendations for each of

the respective dietary interventions. This included whether recommended dietary changes were made, experiences related to making the changes, and whether the participant was likely to maintain the changes. In addition, strategies used to implement these changes were explored.

## Thematic findings

Participants were generally positive about their experience and were keen to share their strategies around implementing dietary changes, especially surrounding foods that they enjoyed. Similarly, dietary changes that involved foods that participants enjoyed were more likely to be reported as a change that would be maintained.

There were three main themes that emerged from the interviews. These were: (1) novelty, (2) convenience and (3) food swapping. These overarching themes were underpinned by two sub-themes; flavour and enjoyment which came through within each of the three main themes and were reflective of perceived adherence to and maintenance of the dietary changes. The relationship between these themes is summarised in the schematic in Figure 1.

### 1. *Novelty enhanced interest and engagement*

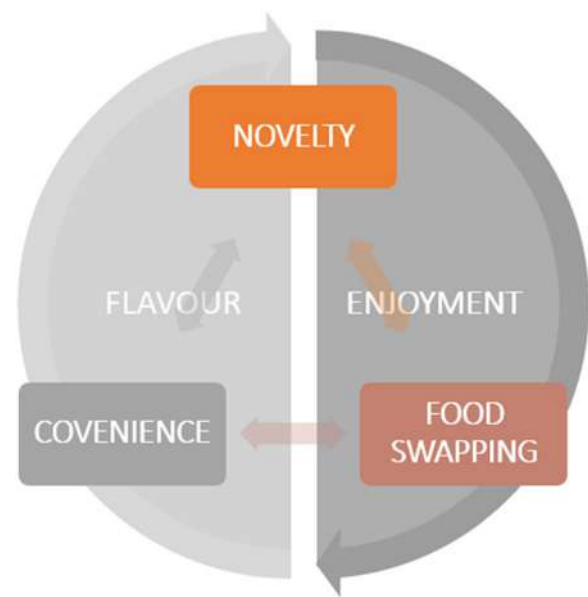
The notion of 'novelty' was used to capture dietary components that were perceived as new, innovative or unfamiliar. This theme encompasses the idea that participants responded with interest when the advice provided included 'new' or less commonly consumed foods, ingredients or recipes. This theme emerged in both the MD and LFD intervention groups, but was conveyed more strongly from MD participants who were less likely to be accustomed with the MD ideologies including the 'prescribed' ingredients, foods, recipes and overall dietary recommendations.

One participant from the MD group who previously did not consume extra virgin olive oil (EVOO) described the experience of introducing EVOO to their family through cooking, saying that:

*[my] whole family made this change and will maintain it*

Another participant from the MD group talked about strategies to increase legume intake, which were not previously consumed. The participants also reported about foods, including legumes that it was helpful '*trying different recipes*'.

By contrast, dietary advice that focused on familiar foods, such as those that participants were already eating or dietary recommendations they had already received in the past, resulted in the perception that there was less scope for change. This



**FIGURE 1** A schematic summarising the key themes that emerged from part two of the semi-structured interviews. Key themes: novelty, convenience and food swapping. Sub-themes: flavour and enjoyment.

perceived barrier about familiar recommendations was reported by the LFD group, which was not unexpected given that dietary recommendations in the LFD were consistent with the more familiar, Australian Dietary Guidelines. When one participant was asked whether they were able to successfully implement low fat cooking methods, they explained that there was little scope for change:

*[I] used very little oil before anyway*

### 2. *Convenience enhanced accessibility and perceived maintenance*

The theme of convenience came through in response to questions about whether participants were able to implement and maintain dietary changes. They reported adopting strategies that made food more accessible within their day-to-day lives. The theme of convenience captures the views that foods, especially those that participants enjoyed, were made more available and as a result were consumed more frequently. Access to foods refers to accessibility within the home and workplace, as well as ensuring that, at meal times, there was something readily available to eat, involving minimal preparation. This theme around convenience was reported by the MD and LFD intervention group participants.

In the MD and LFD groups, participants reported purchasing frozen vegetables, eating '*simple things like salads*' and one participant from the MD group

explained that they prepare their salads in advance for the entire week:

*[I] prepare a Greek salad at the start of the week and store it in the fridge, then [I] eat salad everyday*

Others noted purchasing cans of tuna or legumes and freezing foods as convenience items which facilitated adherence to the prescribed diets.

### 3. **Food swapping** enhanced the sense of simplicity and achievability

Participants across both dietary intervention groups often spoke about food swapping. This theme encompasses the idea that recommended foods were swapped for foods previously consumed as a part of habitual diets.

In the MD group, there were an abundance of strategies listed that utilised the concept of food swapping. For EVOO, participants talked about using the oil to replace butter or margarine in their cooking, one participant explaining:

*[I] use [olive oil] as a dressing on Chinese greens as a replacement for vegetable oil*

Food swapping was also a popular strategy for increasing vegetable and fish consumption and for reducing meat consumption. One participant in the MD group stated:

*[I] replaced meat with legumes or chickpea casseroles*

In the LFD group, this idea of food swapping was adopted to select low fat alternatives, or in reference to using low fat cooking methods.

The notion of food swapping was related to a greater sense of simplicity and ability to achieve dietary changes and where food swapping was reported participants were also more likely to indicate that they would maintain the dietary change.

In addition to the three main themes, there were two sub-themes that developed from the analysis: flavour and enjoyment. These sub-themes ran consistently throughout the interviews and underpinned all three of the main themes. When discussing dietary changes participants described that they were more likely to adopt and maintain changes based on whether the food tasted good (flavour) and this in turn predicted whether they enjoyed it.

### 4. **Flavour and enjoyment** enhanced acceptability, number of strategies surrounding implementation and perceived maintenance

When referring to novelty, convenience or food swapping, participant enjoyment of the food was often associated with flavour. If a food was perceived as having a favourable flavour, the participant was more likely to enjoy the food, and enjoyment was often associated with wanting to and being able to, maintain the dietary change(s). There was a high rate of positive responses from both the MD and LFD group when asked if they enjoyed the dietary changes. However, there were stronger descriptions around flavour and reinforcement of enjoyment of the diet from the MD group.

Some of the language that reinforced these ideas is explored below. A summary of the key words used by participants that assisted in the development of each key theme and sub-theme is included in Table 3. For the inclusion of EVOO one participant in the MD group stated:

*[I] love [the olive oil]*

A participant in the MD group also talked about increasing vegetables in their diet, highlighting their enjoyment:

*[I] include vegetables with every meal, now when there are no vegetables [I] notice and [I] miss them.*

This was also reported by a MD participant in reference to increasing fish consumption:

*[I] enjoyed this change a lot*

When asked if they would maintain the dietary change they responded convincingly; 'yes definitely'.

Conversely, palatability of the LFD was also a perceived barrier to success:

*The hardest part was adjusting to the new diet, stuff just didn't taste quite the same*

**TABLE 3** Main terms that were derived from participant responses for each key and sub-theme

Category	Terms described in participant responses
<i>Key themes</i>	
Novelty	changed, different, new
Convenience	quick, easy, convenient, simple
Food swapping	changed, swap, replace, adjustments
<i>Sub-themes</i>	
Flavour	flavour, taste, palatable, delicious
Enjoyment	enjoy, love, satisfying, favourite, nice



and:

*[I] didn't miss the old diet too much, [I] got used to [the dietary changes] easily, but it was a bit boring at times*

and:

*[I] got used to the diet, but it was nothing special, [the diet] was bland*

Those who did not like the flavour of a food were not likely to perceive that they would sustain the dietary changes made. A participant in the MD group talked about eating more legumes and said:

*[I] didn't enjoy them*

They went on to explain that there was 'no flavour' and they would 'probably not' maintain the change.

Greater overall enjoyment was also associated with reporting a larger number of strategies surrounding implementation and maintenance of the dietary changes.

## DISCUSSION

The present qualitative study aimed to explore participants' experiences and their perceptions of the adoption of dietary recommendations when taking part in an intervention study that aimed to assess the effects of improving diet quality through the adoption of a LFD or a MD in patients with NAFLD (the MEDINA trial). The study is novel in that it assessed acceptability of the interventions which are seldom captured in dietary RCTs. Participants across both dietary intervention groups reported that they enjoyed being involved in the study and felt that they adopted several of the dietary recommendations and they also perceived that they would maintain them beyond the 12-week intervention period. Interestingly many participants reflected that, even without weight loss, they felt better or noticed improvements in their health outcomes at follow up medical appointments.

The results of the present align with the guidelines described in the Theoretical Domains Framework of behaviour change because this study, using qualitative methodology, identifies determinants of behaviour to support implementation problems and support future intervention designs.<sup>10</sup> Key aspects of the intervention delivery that participants felt supported their dietary adherence were goal setting, provision of education resources and food hampers. Goal setting and resources have been reported throughout several dietary interventions including the MD as desirable and effective delivery techniques.<sup>11–13</sup> Other studies support this idea that adherence is likely to be improved when participants are

provided with shopping lists, meal plans and recipes.<sup>14</sup> Food hampers, supplied to the MD participants in this trial, have been employed and endorsed in seminal research trials including the Primary Prevention of Cardiovascular Disease with a Mediterranean Diet study (PREDIMED), as an effective strategy for increasing dietary compliance.<sup>14–17</sup>

Cost of the diet was not mentioned by any of the study participants, which was unexpected given that this is often a perceived barrier for the adoption of 'healthier' diets.<sup>18,19</sup> This was in contrast to an Australian study in healthy individuals where affordability was mentioned as a perceived barrier for MD adherence, and it was also a perceived barrier in a study conducted in Northern Europe where participants had a high risk of cardiovascular disease, although both cohorts had not participated in a clinical trial and were healthy individuals, not specifically those with chronic disease.<sup>19,20</sup> However, participants in the present study did mention a lack of time for meal preparation and difficulty in reducing the intake of refined snacks as barriers, consistent with studies published in both healthy participants and those with chronic disease.<sup>21–24</sup>

When individual dietary recommendations that related to each of the interventions were explored the first theme, novelty was reflected in responses from participants in both the MD and LFD groups; however, it was a more prominent theme in the MD group participants. Dietary recommendations provided for the MD are substantially different (e.g., higher in unsaturated fats) compared to the familiar Australian Dietary Guidelines and this may explain why participants perceived these recommendations as novel. Although there has been a substantial amount of research assessing the MD, much of this has been in Mediterranean populations, and there is a lack of qualitative literature assessing the perceptions of a MD in multicultural populations and indeed those with chronic disease. One previous study reported that participants thought the MD intervention 'widened their food horizons'; this idea supports the importance of novelty that emerged in the current cohort.<sup>25</sup> Furthermore, in the present study, participants described the MD as novel, and this was in part because it was not a common dietary recommendation. This could be explained by lack of application by healthcare providers, a theory that is supported by a study in healthcare providers regarding the MD. Specifically, healthcare providers reported that they had limited education and knowledge to provide advice regarding the Mediterranean dietary pattern and specifically expressed concerns about the ability to implement MD in a multicultural setting.<sup>26</sup>

Convenience, the second theme that emerged was expressed strongly by both the MD and LFD groups. Having access to the recommended, healthy foods with minimal preparation time (such as pre-prepared meals and canned foods) was a feature that appeared to



support participants to adopt dietary changes. This finding is well supported by evidence indicating that convenience is a key factor in driving food choice and probably dietary maintenance.<sup>27–29</sup> Convenient foods were also more likely to be considered by participants as a dietary change that would be maintained. Lack of time has been noted as a key barrier and therefore convenient options assist with overcoming this challenge.<sup>20,21</sup> Participants involved in this trial were supplied with resources and education encouraging convenience.<sup>5</sup>

Interestingly, the third theme, food swapping, was reported by many participants who replaced foods that formed part of their habitual diet with recommended foods from the dietary intervention. This theme emerged for both groups and reiterates that dietitians should make suggestions around dietary changes that align with habitual diets. This is supported by the idea that it is not often realistic to completely overhaul an individual's diet, and recommended changes should be small and sustainable as an important and effective behaviour change technique.<sup>30</sup>

Underlying the three key themes were the sub-themes: flavour and enjoyment. Taste or flavour is also a commonly reported inhibitor of implementing and maintaining healthier dietary patterns and poor (or lack of) flavour was particularly recounted as a barrier from LFD group participants.<sup>24</sup> Participants who reported that the food was palatable also described that they enjoyed the dietary change. This theme emerged from both dietary intervention groups; however, there was more prominent language and reinforcement from the MD group. The MD is renowned for its palatability, which is a known driver of adherence.<sup>31,32</sup> Reasons to support the flavour and enjoyment of the MD include its high fat composition, which leads to richer tastes and satiety,<sup>5</sup> and this may explain why more participants in this group felt that they could sustain the diet.

The main themes derived from this work, are tied together, as shown in the schematic in Figure 1 where the fundamental components surrounding successful implementation of a dietary intervention in NAFLD participants are summarised. This 'plate' shaped model is a tool that may guide the design of future dietary interventions in clinical trials and dietary delivery techniques. This model emphasises the importance of balance between the enablers: novelty, convenience and food swapping, as well as ensuring that dietary advice encompasses flavour and enjoyment. This is especially important because lifestyle intervention is the only demonstrated therapy for people with NAFLD. The generalisability of this model to other chronic disease cohorts is not known and requires application and evaluation within these cohorts.

One of the strengths of this qualitative analysis is that consistent responses were received and participants answered a breadth of questions that provided an overview of both the acceptability of the dietary

intervention based on structure and also specifically surrounding dietary components. This qualitative analysis was also conducted in a unique setting assessing a Mediterranean diet in free-living Australians and therefore evaluates the feasibility of implementing the cuisine and ingredient changes (i.e., cooking with olive oil). Furthermore, these interviews were administered by a researcher who was not involved in providing the dietary counselling and so participants were less likely to present biased responses reflecting what they assumed the researcher would like to hear and the researcher was less likely to ask leading questions.

The limitations of the study relate to the semi-structured interview process; alternatively, a focus group discussion may have facilitated a deeper exploration into some of the barriers and enablers of the dietary intervention. In addition, more background information, such as previous consultations with a dietitian and experience with goal setting, may have provided additional context to participant responses. Measures of self-efficacy were not conducted and may have provided additional insight to the data collected. Finally, contamination between dietary arms is also likely to have occurred because LFD participants were aware of the 'experimental' MD arm and some were disappointed that they were not randomised into this group. Furthermore, the 3-month duration of the study was relatively short and assessment of actual, sustained, dietary changes was not compared with perception in the present investigation. Longer time frames are needed to assess the feasibility of long term maintenance.

## CONCLUSIONS

The present study demonstrated that participants enjoyed taking part in both the MD and LFD interventions. The MD was accepted by an Australian, multi-cultural adult population and there was more emphasis on enjoyment of changes and intention to sustain dietary changes from participants in the MD group compared to the LFD group. Reported factors influencing the uptake and likely maintenance of dietary intervention included delivery techniques including goal setting, provision of resources and food hampers. Novelty surrounding recommendations and foods, convenience and use of food swapping were deemed key enablers to the successful implementation of a dietary intervention. Flavour and enjoyment of food were also fundamental components of the diets with regard to the perceived uptake and increased desire to maintain dietary change, therefore highlighting that dietary recommendations should be designed to be palatable. These findings should be considered in the design of dietary interventions for chronic disease management to ensure acceptable recommendations enhancing participant uptake.

## AUTHOR CONTRIBUTIONS

Elena S. George conceptualised the study. Anjana Reddy was involved in data collection. Elena S. George carried out the analysis with support from Adrienne K. Forsyth to provide a consensus on the interpretation. Elena S. George drafted the manuscript. All authors critically reviewed and approved the final version of the manuscript submitted for publication.

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## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

## TRANSPARENCY DECLARATION

The authors affirm that this manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

## ETHICAL STATEMENT

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Alfred Health, Eastern Health, Melbourne Health and La Trobe University human research ethics committees. Written informed consent was obtained from all subjects/patients.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Antenatal diet quality and perinatal depression: the Microbiome Understanding in Maternity Study (MUMS) cohort

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## Abstract

**Background:** Previous findings from research investigating the role of antenatal nutrition in preventing postpartum depression (PPD) are inconsistent. Our primary aim was to investigate the association between pregnancy diet quality and PPD. Our secondary aim was to investigate associations between (a) diet quality and depression during pregnancy and (b) depression during pregnancy and PPD.

**Methods:** This analysis represents data from 73 women participating in the Microbiome Understanding in Maternity Study (MUMS) cohort in Sydney, Australia, which followed women from Trimester 1 of pregnancy to 1-year postpartum (PP). Participants' diet quality was assessed using the Australian Eating Survey at Trimester 1 and 3 to calculate diet quality, known as the Australian Recommended Food Score (lower diet quality defined as score <39; higher diet quality  $\geq$ 39). Depression was assessed using the Edinburgh Depression Scale at Trimesters 1, 2, 3 and 6 weeks PP (defined as score  $\geq$ 11).

**Results:** Depression scores during pregnancy were significantly associated with depression score 6 weeks PP (Trimester 1:  $r=0.66$ , Trimester 2:  $r=0.69$ , Trimester 3:  $r=0.67$ ; all  $p<0.001$ ). Diet quality during pregnancy was not significantly correlated with 6-week PPD score. In unadjusted analysis, diet quality during pregnancy was not associated with pregnancy depression scores. When adjusted for age, parity and Trimester 1 body mass index, Trimester 1 physical activity levels and gestational weight gain, higher Trimester 3 diet quality was associated with reduced Trimester 3 depression only.

**Conclusions:** Depression scores during pregnancy were positively associated with PPD, highlighting the importance of screening for depression during pregnancy and postnatally. Larger longitudinal prospective studies may elucidate the association between diet quality and PPD.

## KEYWORDS

depression, diet, mental health, postpartum, postpartum period, pregnancy

## Highlights

- Depression during pregnancy was associated with postpartum depression score, highlighting the importance of adhering to routine screening guidelines throughout the perinatal period.



- Although diet is clearly important for the health of both the mother and the developing foetus during pregnancy, our analysis of data from the Microbiome Understanding in Maternity Study (MUMS) cohort did not find any associations between diet quality and depression.

## INTRODUCTION

Postpartum (PP) blues is a transient form of moodiness experienced by ~85% of women 3–4 days PP, which usually dissipates within 1–2 weeks.<sup>1</sup> It becomes a major depressive disorder when the feeling of despondence prolongs, known as postpartum depression (PPD).<sup>1</sup> Approximately 12%–16% of women suffer from PPD worldwide, with a prevalence of 6%–12% in Australia.<sup>2,3</sup> Women experience severe mood swings, extreme sadness and worthlessness that impair their ability to concentrate, leading to deleterious health consequences for the mother and infant.<sup>1</sup> For the mother this includes increased suicide risk, a leading cause of maternal mortality,<sup>4</sup> and impaired mother–infant bonding and interactions, which increase infant risk of growth retardation, social-emotional delay, attenuated cognitive skills and behavioural problems.<sup>5,6</sup>

Although the causes of PPD remain unclear, nutrition has been suggested as one modifiable risk factor.<sup>7</sup> Findings from studies conducted to date investigating the association between antenatal nutrition and PPD are conflicting. A higher diet quality pattern indicative of increased intake of micronutrients and unsaturated fats via higher consumption of vegetables, fruit, pulses, nuts, dairy products, fish and olive oil has been associated with reduced PPD symptoms in two cohort studies,<sup>8,9</sup> whereas two other studies reported no association between higher diet quality and PPD.<sup>10,11</sup> Furthermore, Barker and colleagues reported an association between a poorer diet quality pattern indicative of reduced intake of micronutrients and increased intake of saturated fat via higher consumption of meat, potatoes, sugar and sweets, cereals, fats except olive oil, salty snacks, eggs, beverages and sauces and increased PPD symptoms,<sup>8</sup> whereas three other studies reported no association between poor diet quality and PPD.<sup>9–11</sup> These inconclusive findings could reflect factors such as varying PPD definitions and the limitation that all studies conducted to date have assessed diet only once, yet diet is known to change throughout pregnancy.<sup>12</sup> The use of multiple measurement time points to assess antenatal diet would increase the precision of diet assessment,<sup>13</sup> suggesting the need for well-designed longitudinal studies that measure diet at numerous time points.

Therefore, the primary aim of the present analysis was to assess the association between diet quality during pregnancy and PPD at 6 weeks PP. The secondary aim was to assess associations between diet quality during pregnancy and depression during pregnancy and

depression during pregnancy and PPD. We hypothesised that there would be an inverse association between diet quality and PPD.

## METHODS

The present study represents secondary data analyses from the Microbiome Understanding in Maternity Study (MUMS), an Australian longitudinal prospective cohort study investigating the maternal microbiome in women with low-risk ( $\geq 18$  years, singleton pregnancy, did not meet criteria for high-risk) and high-risk (body mass index [BMI]  $> 30$ , history of gestational or pre-pregnancy diabetes mellitus or history of a hypertensive disorder of pregnancy or chronic hypertension) pregnancies.<sup>14</sup> The cohort recruited 117 mother–infant pairs during 2018 and 2019 who were booked in for pregnancy care at St George Hospital, a socio-demographically diverse area of metropolitan Sydney, Australia, followed from trimester (T)1 of pregnancy through 1-year PP. The primary objective of MUMS was to define the maternal microbiome across pregnancy and to 1-year PP and identify key clinical and environmental variables that shape the female microbiota profile during and after pregnancy. A detailed study protocol has been previously published.<sup>14</sup> Ethical approval was received from the South Eastern Sydney Local Health District Research Ethics Committee (17/293 (HREC/17/POWH/605)), and the written informed consent was obtained from all participants. The inclusion criteria for the present analysis included women enrolled in MUMS, with dietary intake data at T1 or/and at T3 of pregnancy, together with depression data at 6 weeks PP. This resulted in a final sample size of 73 participants and, with power set at 0.8 and alpha set at 0.05, this powers the present analysis to detect a smallest significant correlation of  $r < -0.32$  or  $r > 0.32$ . Depressive symptoms were assessed using the paper-based Edinburgh Depression Scale (EDS),<sup>15</sup> a validated and reliable self-rating scale questionnaire developed to screen depression during pregnancy (T1, T2 and T3) and PP (6 weeks).<sup>16,17</sup> The questionnaire consists of 10 statements, each scored on a four-point scale, rating the intensity of depressive symptoms present in the past week. A higher sum of score, described as the Edinburgh Depression Scale Score (EDSS),<sup>15</sup> reflects elevated severity of depressive symptoms with a range of 0–30. There is no universal consensus on the score used to diagnose PPD. For the present analysis, a score  $\geq 11$  was used to indicate the



presence of major PPD, as suggested by a 2020 systematic review to maximise sensitivity and specificity.<sup>18</sup> Analyses at additional cut-points frequently used to diagnose possible/probable PPD (cut-points 9, 10 and 13) were also conducted to confirm findings.

Dietary intake was assessed using the online Australian Eating Survey (AES), a validated and reliable self-administered semi-quantitative food frequency questionnaire (FFQ), designed for the Australian population.<sup>19</sup> The AES consists of 120 dietary questions (foods, drinks, food groups, macronutrients, micronutrients), asking about the frequency of consumption over the previous 6 months ranging from 'never' to '≥7 times per day' in relation to standard adult portion sizes<sup>19</sup> and 15 supplementary questions (about vitamin supplements usage, food behaviours and sedentary behaviours). Of the 120 dietary questions, 70 focus on the consumption of eight dietary components consistent with the Australian Dietary Guidelines (ADG): vegetables (20 questions), fruit (12 questions), meat/flesh foods (7 questions), meat/flesh alternatives (6 questions), grains (12 questions), dairy (10 questions), water (1 question) and spreads/sauces (2 questions).<sup>19</sup> Individual mean daily macro- and micronutrient intakes were computed from the FFQ using the AUSNUT 2011–2013 Australian food composition database.<sup>20</sup>

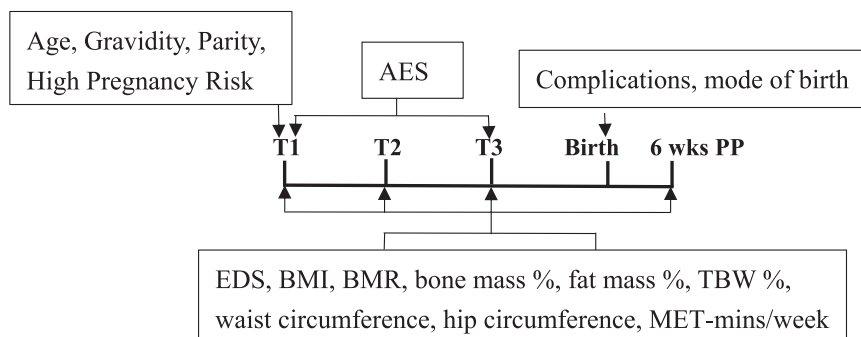
Responses to the AES FFQ were also used to calculate the diet quality score, described as the Australian Recommended Food Score (ARFS).<sup>21</sup> One ARFS point is awarded for a reported frequency consumption aligned with the ADG. The overall ARFS equates to the sum of ARFS points from the eight dietary components with a possible score ranging from 0 to 73 points. The ARFS can then be categorised into four ranks: needs work (<33), getting there (33–38), excellent (39–46), outstanding (47+).<sup>21</sup> Due to the small sample size in the present study, for our analysis we combined diet quality ranks as follows: needs work–getting there (<39) indicating lower diet quality and excellent–outstanding (≥39) indicating higher diet quality.

Other variables studied in the present analysis included age, gravidity, parity, rate of high-risk pregnancy, presence of pregnancy complications (i.e., gestational diabetes, preeclampsia, gestational hypertension), mode of birth, anthropometry (body mass index [BMI], waist circumference, hip circumference), body composition (bone mass %, fat mass %, total body water %) assessed using multichannel bioimpedance analysis (Bodystat 1500: Bodystat Ltd.)<sup>22</sup> and level of physical activity (reported as metabolic equivalent of task [MET] min/week) assessed using the validated self-administered International Physical Activity Questionnaire – Short Form survey.<sup>23</sup> Time points of data collection are summarised in Figure 1.

Statistical analyses were performed using IBM SPSS Statistics, v27. Participants included and excluded in our analysis were (a) characterised using descriptive statistics and (b) compared using independent sample *t*-tests (continuous variables) and chi-square tests (categorical variables) as appropriate.

Bivariate Pearson's correlations were performed as appropriate to assess the associations between (a) diet quality (ARFS) at T1, T3 and depression (EDSS) at T1, T2, T3 and 6 weeks PP, (b) dietary intake of foods and nutrients of interest (i.e., core foods, non-core foods, the five food groups, the three macronutrients [including types of fats, sugar and fibre] and seven micronutrients of interest that have previously been suggested to play a role in the development of depression [thiamine, riboflavin, niacin, folate, sodium, magnesium, zinc]) at T1, T3 and EDSS at T1, T2, T3 and 6 weeks PP, and (c) EDSS at T1, T2, T3 and EDSS at 6 weeks PP. Multiple linear regression was also used to adjust for age, parity, T1 BMI, T1 physical activity levels and gestational weight gain (T1–T3) due to their previously reported association with depression and/or diet quality in previous antenatal studies.<sup>24–26</sup>

Independent sample *t*-tests were performed to compare the mean in ARFS (T1, T3) between EDSS <11 and ≥11 groups and Mann–Whitney *U* tests were used to compare the mean in EDSS (T1, T2, T3 and 6 weeks PP) between the



**FIGURE 1** Timeline of data collection relevant to the present secondary data analysis of the MUMS cohort study. AES, Australian Eating Survey; BMI, body mass index; BMR, basal metabolic rate; EDS, Edinburgh Depression Scale; MET, metabolic equivalent of task; MUMS, Microbiome Understanding in Maternity Study; PP, postpartum; T1, trimester 1; T2, trimester 2; T3, trimester 3; TBW, total body weight; wks, weeks.

**TABLE 1** Characteristics of the MUMS cohort eligible for this sub-study

Participant characteristics	Descriptive	<i>n</i>		
Age in years, <i>M</i> ± <i>SD</i>	34.0 ± 4.4	73		
Ethnicity, <i>n</i> (%)	-	73		
Asian	13 (18)	-		
Middle Eastern	2 (3)	-		
Latino/Hispanic	3 (4)	-		
White	51 (70)	-		
Mixed	2 (3)	-		
Other	2 (3)	-		
Gravidity, <i>n</i> (%) <sup>a</sup>	-	73		
Nulligravida (0)	1 (1)	-		
Primigravida (1)	24 (33)	-		
Multigravida (>1)	48 (66)	-		
Parity, <i>n</i> (%) <sup>a</sup>	-	73		
Nullipara (0)	27 (37)	-		
Primipara (1)	29 (40)	-		
Multipara (>1)	17 (23)	-		
High risk pregnancy, <i>n</i> (%) <sup>a</sup>	32 (44)	73		
Complications, <i>n</i> (%)				
Gestational diabetes	11 (16)	70		
Preeclampsia	4 (6)	72		
Gestational hypertension	6 (8)	72		
EDSS, median (IQR)				
T1	3.0 (0.5–5.5)	68		
T2	4.0 (1.5–6.5)	70		
T3	3.0 (0.0–6.0)	70		
PPD 6 weeks	4.0 (1.0–7.0)	73		
No. of participants with EDSS ≥ 11				
T1 <i>n</i> (%)	10 (14)	70		
T2 <i>n</i> (%)	9 (13)	70		
T3 <i>n</i> (%)	5 (7)	70		
PP 6 weeks <i>n</i> (%)	7 (10)	73		
Gestational weight gain (T1 to T3), kg <i>M</i> ± <i>SD</i>	9.8 ± 4.0	72		
Participant characteristics	T1	T3	T1	T3
BMI, <i>M</i> ± <i>SD</i>	25.9 ± 5.4	30.0 ± 5.5	73	72
<18.5 kg/m <sup>2</sup> <i>n</i> (%)	1.00 (1)	0.00 (0)	-	-
18.5–24.9 kg/m <sup>2</sup> <i>n</i> (%)	39.0 (53)	14 (19)	-	-
≥25 kg/m <sup>2</sup> <i>n</i> (%)	33.0 (45)	58 (81)	-	-
Fat mass %, <i>M</i> ± <i>SD</i>	33.3 ± 8.0	37.3 ± 6.4	71	72

(Continues)

**TABLE 1** (Continued)

Participant characteristics	T1	T3	T1	T3
ARFS <i>M</i> ± <i>SD</i>	35.5 ± 10	36.9 ± 10	71	64
Outstanding 47 + <i>n</i> (%)	11 (15)	13 (20)	-	-
Excellent 39–46 <i>n</i> (%)	16 (23)	18 (28)	-	-
Getting there 33–38 <i>n</i> (%)	15 (21)	8 (13)	-	-
Needs work <33 <i>n</i> (%)	29 (41)	25 (39)	-	-

Abbreviations: ARFS, Australian Recommended Food Score; EDSS, Edinburgh Depression Scale Score; IQR, interquartile range; *M*, mean; MUMS, Microbiome Understanding in Maternity Study; *n*, number of participants from cohort of 73; PP, postpartum; SD, standard deviation; T1, Trimester 1; T2, Trimester 2; T3, Trimester 3.

<sup>a</sup>At the start of pregnancy.

two predefined ARFS (T1, T3) ranks (needs work–getting there [ $<39$ ]) and (excellent–outstanding [ $\geq 39$ ]).

## RESULTS

Of the 117 participants recruited to the MUMS cohort study, 1 was lost to follow-up, 11 withdrew and 6 were excluded from the primary study. For the present study, a further 14 participants were excluded due to missing dietary data at T1 and T3, and 12 were excluded due to missing depression data at 6 weeks PP, leaving 73 participants in this analysis. Participants included in the present analysis were more likely to be Caucasian, had their babies at a slighter later gestational age and were on average 2 years older than those excluded (Tables S1 and S2). The EDSS at T1 was significantly higher in those excluded from analysis compared with those included in analysis (Table S2).

Characteristics of the cohort are presented in Table 1. Participants had a mean ± SD age of 34.0 ± 4.4 years, and the majority were of White or Asian ethnicity. The mean EDSS was <11 at all time points, and the proportion of participants with an EDSS ≥ 11 ranged from 7% to 14% at all time points. The cohort's diet consisted of 69% and 67% of energy from core foods (31% and 33% from non-core foods) at T1 and T3, respectively. Further details are found in Table S3.

ARFS during pregnancy at T1 and T3 was not associated with EDSS at 6 weeks PP (Table 2), including after adjustment for age, parity, T1 BMI, T1 physical activity levels and gestational weight gain. Similarly, unadjusted analysis indicated that ARFS during pregnancy at T1 and T3 was not associated with EDSS during pregnancy at T1, T2 or T3 (Table 2). In adjusted analysis, T3 ARFS was associated with T3 depression (regression coefficient B [95% confidence intervals]: 0.16

[0.03–0.29];  $p = 0.017$ ) only. When comparing participants with a lower diet quality with those who had a higher diet quality, no statistically significant difference in 6-week PP EDSS was observed at T1 or T3 (Table 3). Similarly, when

**TABLE 2** Correlations between diet quality during pregnancy and antenatal and PP depression

ARFS and EDSS	Pearson's correlation ( <i>r</i> )	<i>p</i> -Value	<i>n</i>
T1 ARFS and EDSS PP 6 weeks	-0.16	0.18	70
T3 ARFS and EDSS PP 6 weeks	0.03	0.81	64
T1 ARFS and EDSS T1	-0.14	0.25	67
T1 ARFS and EDSS T2	-0.05	0.68	68
T1 ARFS and EDSS T3	-0.09	0.48	68
T3 ARFS and EDSS T3	0.19	0.14	62

Abbreviations: ARFS, Australian Recommended Food Score; EDSS, Edinburgh Depression Scale Score; *n*, number of participants from cohort of 73; PP, postpartum; (*r*), bivariate Pearson's correlation analysis; T1, Trimester 1; T2, Trimester 2; T3, Trimester 3.

categorised into the two EDSS groups (i.e., depression score: <11 vs. ≥11) no difference in diet quality (ARFS) at T1 or T3 between the two EDSS groups at 6 weeks PP was observed (Table 4). Similarly, there were no significant differences in diet quality between those above or below the EDSS cut-points during pregnancy (Tables 3 and 4). There were no differences in diet quality or depression score at any time point among women who took supplements at T1 (90% of women) and/or T3 (88% of women) compared with those who did not.

Specific food groups and nutrients associated with higher depression scores throughout pregnancy and at 6 weeks PP are outlined in Table 5. Correlations of all food groups/nutrients with depression scores throughout pregnancy and at 6 weeks PP are shown in Table S4.

Higher EDSS at each time point in pregnancy (T1, T2 and T3) was significantly associated with a higher EDSS at 6 weeks PP in unadjusted analysis (Table 6). These associations did not change when adjusted for age, parity, T1 BMI, T1 physical activity levels and gestational weight gain.

**TABLE 3** Antenatal and postnatal depression scores of women with low versus high diet quality during pregnancy, median (IQR)

	PP 6 weeks			T1 depression			T2 depression			T3 depression		
	EDSS	<i>n</i>	<i>p</i> -Value	EDSS	<i>n</i>	<i>p</i> -Value	EDSS	<i>n</i>	<i>p</i> -Value	EDSS	<i>n</i>	<i>p</i> -Value
T1 lower diet quality	3.5 (0.5–6.5)	44	-	3.0 (0.5–5.5)	40	-	3.5 (1.5–5.5)	42	-	3.0 (0.0–6.0)	42	-
T1 higher diet quality	5.0 (2.0–8.0)	27	0.52	3.5 (0.0–7.0)	26	0.98	4.0 (1.5–6.5)	27	0.59	4.0 (0.5–7.5)	27	0.78
T3 lower diet quality	4.0 (1.0–7.0)	33	-	-	-	-	-	-	-	3.0 (0.5–5.5)	32	-
T3 higher diet quality	4.0 (2.5–5.5)	31	0.54	-	-	-	-	-	-	3.5 (0.0–7.0)	30	0.29

Abbreviations: EDSS, Edinburgh Depression Scale Score; IQR, interquartile range; *n*, number of participants from cohort of 73; T1, Trimester 1; T2, Trimester 2; T3, Trimester 3.

**TABLE 4** Diet quality during pregnancy in women with versus without depressive symptoms during pregnancy and PP

	T1 diet			T3 diet		
	ARFS <i>M</i> ± <i>SD</i>	<i>n</i>	<i>p</i> -Value	ARFS <i>M</i> ± <i>SD</i>	<i>n</i>	<i>p</i> -Value
PP 6 weeks <11 EDSS	35.9 ± 9.5	64	0.28	36.9 ± 9.3	59	0.96
PP 6 weeks ≥11 EDSS	31.6 ± 14.2	7		37.4 ± 19.4	5	
T1 < 11 EDSS	36.4 ± 9.5	57	0.19	37.6 ± 9.5	53	0.36
T1 ≥ 11 EDSS	31.6 ± 13.8	9		33.9 ± 15.0	7	
T2 < 11 EDSS	36.2 ± 9.1	63	0.79	37.4 ± 9.3	56	0.53
T2 ≥ 11 EDSS	34.5 ± 14.4	6		32.3 ± 18.0	6	
T3 < 11 EDSS	36.0 ± 9.4	64	0.69	36.4 ± 10.0	58	0.11
T3 ≥ 11 EDSS	32.6 ± 17.5	5		45.0 ± 12.5	4	

Note: Lower diet quality = ARFS < 39; higher diet quality = ARFS ≥ 39; EDSS cut-off point used to indicate major depression ≥ 11.

Abbreviations: ARFS, Australian Recommended Food Score; EDSS, Edinburgh Depression Scale Score; IQR, interquartile range; *M*, mean; *n*, number of participants from cohort of 73; PP, postpartum; *SD*, standard deviation; T1, Trimester 1; T2, Trimester 2; T3, Trimester 3.

**TABLE 5** Specific food groups and nutrients associated with higher score on the Edinburgh Depression Scale at Trimester 1 and Trimester 3 of pregnancy

Higher depression scores	Trimester 1 diet factors	Trimester 3 diet factors
Trimester 1	Less dairy intake	-
Trimester 2	Greater sweetened drink intake	-
Trimester 3	-	Greater sugar, packaged snack and magnesium intakes
Postpartum depression	Less daily fruit intake	Smaller % energy from core foods

**TABLE 6** Correlations between antenatal depression and postnatal depression

	Pearson's correlation ( <i>r</i> )	<i>p</i> -Value	<i>n</i>
T1 EDSS and EDSS PP 6 weeks	0.66	<0.001	70
T2 EDSS and EDSS PP 6 weeks	0.69	<0.001	70
T3 EDSS and EDSS PP 6 weeks	0.67	<0.001	67

Abbreviations: EDSS, Edinburgh Depression Scale Score; *n*, number of participants from cohort of 73; PP, postpartum; (*r*), bivariate Pearson's correlation analysis; T1, Trimester 1; T2, Trimester 2; T3, Trimester 3.

## DISCUSSION

To the best of our knowledge, this is the first study to examine associations between multiple assessments of antenatal diet quality and PPD. Overall, our results suggest that diet quality, during early or late pregnancy, does not influence the development of depression at 6 weeks PP, nor does antenatal diet quality influence the presence of depressive symptoms during pregnancy. However, an EDSS indicating higher risk for antenatal depression was associated with an increased depression score at 6 weeks PP.

An association between antenatal diet and perinatal depression is biologically possible.<sup>27</sup> Nutrition plays a role in modulating hormonal, immunological and biochemical processes, all of which are associated with the development of depression, suggesting that nutrition plays a plausible role in the development of this multifactorial illness.<sup>27</sup> The significant physical, physiological and immunological changes that a woman's body undergoes during pregnancy and PP mean that women are particularly susceptible to nutrient deficiencies resulting from suboptimal dietary intake during this life stage.<sup>27</sup> This in turn may influence the mechanisms that underlie depression.<sup>28</sup> Bolton and colleagues have proposed a detailed mechanism of how perinatal consumption of a Western diet may increase the risk of PPD whereby high plasma level of branched-chain amino acids, typical of a Western diet, competes with mood-altering neurotransmitter precursors crossing the blood brain barrier, reducing the production of neurotransmitters including dopamine, histamine and serotonin, consequently, increasing PPD risk.<sup>28</sup>

Despite the plausible mechanism, we did not find an association between antenatal diet quality and depression at any time point, including our primary time point at 6 weeks

PP. This finding is in line with three studies that found healthy<sup>10,11</sup> and unhealthy<sup>9–11</sup> diets during pregnancy were not associated with PPD symptoms at 8 weeks,<sup>9</sup> 10 weeks,<sup>9</sup> 2 months,<sup>10</sup> 3 months<sup>11</sup> and 9 months<sup>10</sup> PP, respectively. However, our findings are in contrast with Barker et al. and Chatzi et al. that healthy<sup>8,9</sup> and unhealthy<sup>8</sup> antenatal diets were significantly associated with decreased<sup>8,9</sup> and increased<sup>8</sup> PPD symptoms, respectively.

We also did not find any significant associations between antenatal diet and antenatal depression. This is in contrast to findings from a narrative review of 27 studies which concluded that antenatal depression was a barrier to good antenatal diet quality with 22 of 27 studies finding an inverse association between these two outcomes.<sup>29</sup> Despite the lack of associations between diet quality and depression observed in the present study, diet clearly remains an important factor for the health of both the mother and the developing foetus during pregnancy for a variety of reasons, including foetal/child growth and risk of subsequent cardiometabolic disease.<sup>30,31</sup>

To provide a comprehensive investigation of the associations between antenatal diet and depression, we also conducted correlation analysis between specific food groups/nutrients and depression. In these analyses we demonstrated significant associations between depression and particular dietary items. For example, increased depression scores during pregnancy or at 6 weeks PP were associated with reduced dairy, increased sweetened drinks, sugar, packaged snacks, magnesium intakes and increased non-core foods, reduced core foods and fruit intake. However, these associations did not track throughout the whole pregnancy and PP time course and, although findings are in accordance with some other literature,<sup>12</sup> it is possible that these represent chance findings given that we did not correct for type 1 error



which may have existed given the number of correlation analyses run as part of this study.<sup>32</sup> Therefore, these findings should be interpreted with caution.

Our study also identified a significant association between higher depression scores during pregnancy and 6 weeks PP. This is in keeping with multiple prior longitudinal cohort studies, which have shown that about 40% of women with elevated depressive symptoms PP also had elevated depression scores during pregnancy.<sup>31,33–36</sup> Furthermore, antenatal depression has consistently been identified as a risk factor for PPD.<sup>37–39</sup> This highlights the importance of screening for depression throughout the antenatal period, to not only treat antenatal depression, but also to prevent postnatal depression. This is in line with the 2017 Australian Clinical Practice Guideline Mental Health Care in the Perinatal Period, which recommends routine, universal antenatal and postnatal mental health screening including monitoring and repeating in 2–4 weeks for women with an initial EPDS score between 10 and 12, and arranging further assessment for woman with an EPDS score of 13 or more.<sup>40</sup>

Strengths of this study include the longitudinal assessment of both diet quality and depression throughout the perinatal period. We also conducted our analysis at multiple EDSS cut-points, with results unchanged, adding further strength to our findings. Furthermore, our assessment of depression at 6 weeks PP aligns with the 2017 Australian Clinical Practice Guideline Mental Health Care in the Perinatal Period recommendation to first screen for postnatal depression at 6–12 weeks PP.<sup>40</sup> This time point at 6 weeks PP also allowed for the association between antenatal diet and PPD to be assessed with minimal influence from postnatal confounders. Although diet assessments are imperfect by nature, the use of the AES to assess diet quality was a strength of this study as it is well validated, provided a detailed assessment of the maternal diet and accounts for increased nutritional needs during pregnancy. However, we could not account for the influence of supplement use on nutrient intake as the AES does not record the brand, type or dosage which is a limitation. Although both the AES and EDS are self-reported questionnaires, both are validated and reliable. However, participants reported energy intake of  $7855 \pm 2706$  kJ/day (46% energy from carbohydrates, 19% energy from protein and 35% energy from fat) in T1 and  $8319 \pm 2416$  kJ/day (45% energy from carbohydrates, 19% energy from protein and 36% energy from fat) in T3. This is below the recommended dietary intake for pregnant women<sup>41</sup> suggesting some level of underreporting which is typical of self-report surveys. Other methods of dietary assessment, including doubly labelled water and weighed food records, were considered to be not practical or acceptable in this population, and assessment of plasma carotenoids, although useful for indicating fruit and vegetable intake, does not address the main problem of underreporting of calories observed in our cohort. Of note, the AES has been validated against doubly labelled water,<sup>42</sup> plasma carotenoids<sup>43</sup> and

fatty acids<sup>44</sup> in adult comparative studies. Participants in our study received ongoing care fortnightly throughout their pregnancy from an obstetrician who delivered both health and social support. This high level of support could have significantly improved participants' depressive feelings and eating habits, which may have influenced our findings. The development of PPD is a multifactorial process of which nutrition may be but one modifiable risk factor.<sup>7</sup> Although we were able to adjust for age, parity, T1 BMI, T1 physical activity levels and gestational weight gain, our present analysis did not adjust for other factors known to influence depression and/or diet quality including socio-economic status<sup>45</sup> and history of depression.<sup>24</sup> Although not significant, at both T1 and T3, diet quality was reduced in women who scored  $\geq 11$  on the EDS compared with those who did not, suggesting that our study may not have been powered to find a significant difference which is a common limitation of secondary analyses. In addition, there were some socio-demographic differences between the included and excluded cohort, so findings may be less applicable to a non-Caucasian, younger cohort. Excluded participants also had higher depression scores in T1 which may have affected our findings and requires further investigation. Finally, our sample size of 73 participants had limited power to detect significant associations between outcomes of interest.

Future studies assessing the association between pregnancy diet quality and PP or antenatal depression should ensure supplement usage is suitably accounted for. Furthermore, standardisation of a cut-off point for the detection of depression would allow more direct comparisons to be made between studies.

In conclusion, antenatal diet quality was not associated with perinatal depression. More studies are warranted to further investigate this multifaceted relationship, including longitudinal studies with standardised methodology, a larger sample size and detailed supplement usage. Antenatal depression scores were predictive of higher-risk PPD scores, highlighting the need to adhere to routine screening guidelines throughout the perinatal period.

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## AUTHOR CONTRIBUTIONS

Amanda Henry, Daniella Susic and Maria E. Craig contributed to conception of the MUMS cohort study. Daniella Susic collected data. Megan L. Gow and Hiba Jebeile designed this sub-study. Megan L. Gow and Yei W. I. Lam conducted statistical analyses, data interpretation and prepared the manuscript. All other authors provided intellectual input in revisions of the manuscript and contributed to finalising and approving the final version of the manuscript. The content of the present study has not been published elsewhere.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## TRANSPARENCY DECLARATION

Dr. Gow affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. Dr. Gow affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned (prospectively registered with Australian New Zealand Clinical Trials Registry: ACTRN12618000471280; <https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=374454%26isReview=true>) have been explained.

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## PEER REVIEW

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# B vitamins and homocysteine as determinants of bone health: A literature review of human studies

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## Abstract

Although there are several factors related to bone diseases such as physical activity, gender (oestrogen), race/ethnicity, smoking and alcohol habits, nutrition is a modifiable risk factor that could be employed to prevent or manage the onset of bone health diseases such as osteoporosis in humans. Aside from calcium and vitamin D, B vitamins are a group of water-soluble vitamins that play a vital role in cell metabolism. In this review, current evidence on B vitamins and bone health is assessed. Clinical trials (interventions) indicate that treatment with B vitamins impact the concentrations of total plasma/serum homocysteine concentrations (tHcy); however, most studies have reported the lack of an effect of low homocysteine concentrations on bone turnover markers, bone mineral density or fracture risks. Current studies have been inconsistent in their reports on the role of B vitamins and homocysteine in bone health. More data are therefore required to show the mechanism and effect of tHcy and B vitamins on bone mineral density, bone metabolism and fracture risk.

## KEYWORDS

BMD, bone health, bone metabolism, B vitamins, homocysteine, osteoporosis

## Key points

- B vitamins are important for the regeneration of tissues and organs.
- This review shows that B vitamins may contribute to increased osteogenesis.
- When administered in the normal range, the bioavailability of B vitamins may be beneficial.
- More interventions and longitudinal studies are needed for the effect of B vitamins and homocysteine.

## INTRODUCTION

There is an exponential increase in the risk of osteoporosis and bone fractures with age after menopause in women. Furthermore, women aged 50 years and above are more prone to the risk of hip fractures.<sup>1</sup> Several factors are considered to be related to the risk of age-related bone disorders, such as gender, loss of oestrogen, ethnicity, sedentary lifestyle, excessive alcohol use,

smoking and an unhealthy nutrient-deficient diet devoid of calcium and vitamin D. The role and impact of B vitamins has, however, emerged as an interesting diet-related nutrient that could affect bone metabolism through their singular actions and through modulation of homocysteine concentrations in the body.<sup>2</sup>

Homocysteine is an amino acid that is not supplied from the diet but is synthesised from methionine, an essential amino acid. Normal plasma blood sample

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ranges of homocysteine concentrations for men and women are typically between 5 and 15  $\mu\text{mol L}^{-1}$ , and hyperhomocysteine has been reported as concentrations exceeding 15  $\mu\text{mol L}^{-1}$ .<sup>3</sup> It can be converted to cysteine and methionine by the combination B vitamins (such as folate, B<sub>6</sub> and B<sub>12</sub>) and the enzyme methylenetetrahydrofolate reductase (MTHFR).<sup>4</sup> Homocysteine levels are often categorised into three medical groups for reference: moderate (16–30  $\mu\text{mol L}^{-1}$ ), intermediate (31–100  $\mu\text{mol L}^{-1}$ ) and severe (over 100  $\mu\text{mol L}^{-1}$ ).<sup>5</sup>

The conversion of homocysteine to methionine is called remethylation and this process requires vitamin B<sub>12</sub> as a cofactor. Methionine can subsequently be regenerated to homocysteine by breaking down *S*-adenosylmethionine. During the transsulfuration reaction, cysteine is also generated from homocysteine with pyridoxal-5'-phosphate and cystathionine B-synthase acting as catalysts.<sup>6</sup> The elevation of homocysteine has, however, been suggested to be caused by disruptions to any one of these reactions and a common cause of hyperhomocysteinaemia is known to be the inadequacy of the enzyme MTHFR as a result of genetic defects.<sup>7</sup>

Thiamin (vitamin B<sub>1</sub>) and in its active form thiamine pyrophosphate is an essential micronutrient that acts as a cofactor of key enzymes involved in the process of carbohydrate, lipid and amino acid metabolism, as well as in the synthesis of neurotransmitters. It cannot be made by the body, but is used by the body to metamorphose energy from food.<sup>8</sup>

Riboflavin (vitamin B<sub>2</sub>), is a key component of coenzymes involved with the metabolic pathways in growth of cells, energy production, and the breakdown of fats, steroids and medications. Biologically active forms of riboflavin are flavin adenine dinucleotide and flavin mononucleotide. Because of ageing and reduced absorption efficiency in the elderly, they are more susceptible and vulnerable to vitamin B<sub>2</sub> deficiencies.<sup>9</sup>

Niacin, an essential human nutrient otherwise known as vitamin B<sub>3</sub> or nicotinic acid are substrates for both nicotinamide adenine dinucleotide (NAD) and NAD phosphate (NADP). These coenzymes are known electron acceptors for fuel molecules in redox reactions. Niacin exerts antioxidant effects and is involved in conversion of nutrients to energy, DNA formation and repair, and cellular activities.<sup>9,10</sup>

Vitamin B<sub>6</sub> (pyridoxine) is important for many enzymatic functions (>100) and its role in neurotransmitters, cognitive function, the immune system and in cellular and amino acid metabolism is essential.<sup>10</sup> The bioactive form is known as pyridoxal-5'-phosphate and is also involved in the metabolism of glycogen and phospholipids.<sup>9</sup>

Folate (vitamin B<sub>9</sub>) plays a critical role in the nucleotide synthesis, homocysteine metabolism and in DNA, RNA, protein, and phospholipid methylation. Folate and vitamin B<sub>12</sub> play a vital role in the methylation pathway of methionine synthesis; therefore,

their deficiencies cause megaloblastic changes to the bone marrow and tissues.<sup>9</sup>

Vitamin B<sub>12</sub> is involved in DNA synthesis and normal haematological processes as well as in cognitive and neuro-psychiatric functions. In addition, folate's role in amino acid metabolism responsible for the synthesis of DNA and RNA is essential for the body.<sup>2</sup> Because of the role that vitamins B<sub>6</sub>, B<sub>12</sub> and folate play in the biochemistry of homocysteine, as well as in drug-nutrient interactions in cases such as proton pump inhibitors (PPIs), a medicine sometimes used for the treatment of indigestion (e.g., omeprazole) can elevate homocysteine.<sup>11,12</sup> Causes of deficiencies of these vitamins include alcohol abuse, malabsorption in pernicious anaemia, atrophic gastritis and intestinal diseases (Crohn's disease and coeliac disease). Medications such as methotrexate and metformin could also result in B vitamin deficiency and can elevate homocysteine. Inadequate dietary intake in cases such as veganism and vegetarianism could also result in a low vitamin B<sub>12</sub> status.

Elevated concentrations of homocysteine have been correlated with several conditions such as increased cerebrovascular, cardiovascular and thromboembolic diseases.<sup>4,6,13</sup> Cognitive ability decline, chronic kidney disease, Alzheimer's disease, hypothyroidism and schizophrenia have also been linked to high concentrations of homocysteine.<sup>14–16</sup> These studies have shown that lowering homocysteine concentrations can be beneficial in lowering the risk for cardiovascular and cerebrovascular disease. However, reports have been controversial. A study showed the beneficial effects of lower homocysteine concentrations in slowing down the acceleration rate of brain atrophy<sup>14</sup>; however, another meta-analysis by the American Heart Association showed that a lower homocysteine level does not positively impact coronary heart disease<sup>17</sup> or prevent stroke.<sup>13</sup>

In addition, hyperhomocysteinaemia has been linked to osteoporosis and increased hip fracture in women, most especially postmenopausal women. The pathophysiology is speculated to be the result of an alteration of the bone matrix when homocysteine interferes in the collagen cross-linking leading to increase in bone fragility.<sup>18</sup> Elevated homocysteine negatively influences the formation of bone matrix by the inhibition of collagen cross-linking enzyme lysyl oxidase (Lox), as well as a possible repression of its mRNA expression. Plasma total homocysteine concentration is influenced by B vitamins including riboflavin (vitamin B<sub>2</sub>). Low concentrations of these vitamins cause elevated plasma total homocysteine, with the main nutritional determinant being low vitamin B<sub>12</sub>, such that folate fortification is employed in most countries.<sup>19</sup> Folic acid fortification is, however not generally used because not all countries allow fortification of the food supply, which creates complications in the analysis of evidence and data in studies.



Pyridoxine (vitamin B<sub>6</sub>) acts as an essential co-enzyme for lysyl oxidase, which is an enzyme necessary for collagen cross-linking. Pyridoxine is also known for physiological activities in hormone receptors because of its role in the regulation of steroid hormones such as oestrogen.<sup>20</sup> Apparently, the relationship between B vitamins and bone metabolism is multifactorial and interwoven with other metabolic pathways in the skeletal system.

Therefore, the primary objective of this scoping narrative/literature review is to provide an updated summary of available data on the correlation between B vitamins, homocysteine and bone health in observational studies (Tables 1 and 2), clinical trials and meta-analyses (Table 3).

In September 2021, a search was carried out in the Massey University library Discover using PubMed, Google Scholar and Web of Science. The search words B vitamins, homocysteine and bone were used. Relevant papers were then used in the finalisation of the study (Table 4).

## DISCUSSION

Most of the cross-sectional epidemiological studies on B vitamins (both in diet recall and blood samples) and bone health have largely been on cobalamin (vitamin B<sub>12</sub>). Not many cross-sectional studies have been conducted on the other B vitamins.

## THIAMIN

Two studies were conducted over two decades ago, with one of the studies reporting thiamin status in orthopaedic patients and indicating a deficiency of thiamin in patients with femoral neck fracture.<sup>67</sup> The other study reported a high proportion of falls that may be a result of moderate and severe thiamin deficiency in aged hospitalised patients.<sup>68</sup>

## RIBOFLAVIN

Three cross-sectional studies were conducted on vitamin B<sub>2</sub> (riboflavin) and bone health. One of the studies reported a positive correlation between vitamin B<sub>2</sub> intake and femoral neck BMD in *TT* genotype women.<sup>39</sup> *MTHFR* genotype was associated with femoral neck and lumbar spine BMD indicating a reduced activity of the *MTHFR* enzyme in the *TT* genotype as a result of the loss of B<sub>2</sub> cofactor.<sup>10</sup> One of the other two studies found a positive association between vitamin B<sub>2</sub> and lumbar spine BMD,<sup>40</sup> whereas the third study found no association with vitamin B<sub>2</sub> and bone density.<sup>38</sup> In

longitudinal studies, three studies conducted showed a positive relationship between vitamin B<sub>2</sub> and BMD; in Scottish women with *MTHFR TT* genotype<sup>48</sup> and in Dutch participants.<sup>49,51</sup>

## NIACIN

Likewise, in a cross-sectional study conducted in New Zealand postmenopausal women, vitamin B<sub>3</sub> was positively associated with spine, femoral neck, hip and whole-body BMD.<sup>40</sup> Similarly, premenopausal intake of niacin (vitamin B<sub>3</sub>) in a Japanese women was positively correlated with BMD.<sup>69</sup> However, in the Singaporean Chinese Health Study, dietary intake of vitamin B<sub>1</sub>, B<sub>2</sub> and B<sub>3</sub> was not associated with risk of fracture in the men or women.<sup>52</sup>

## PYRIDOXINE

Three out of five cross-sectional studies that measured the correlation between pyridoxine (vitamin B<sub>6</sub>) and bone mass and/or fracture risk found a significant association. The Danish osteoporosis prevention study showed a positive association between vitamin B<sub>6</sub> and BMD<sup>39</sup>; similarly, in German men and women, a positive association was found between serum vitamin B<sub>6</sub> and trabecular number in subjects.<sup>28</sup> An inverse association was also found in Chinese women residents between vitamin B<sub>6</sub> and osteoporosis risk, whereas no association was observed in men.<sup>34</sup> Two studies, however, found no association between vitamin B<sub>6</sub> and BMD; this may be a result of the small sample size and/or study design. More relevant prospective studies are therefore needed to validate the results.

In the Rotterdam study, a positive association was observed between vitamin B<sub>6</sub> and femoral neck BMD and an inverse relationship was observed with vitamin B<sub>6</sub> and fracture risk.<sup>49</sup> Similarly, the Framingham Osteoporosis study reported an inverse association between vitamin B<sub>6</sub> and bone loss/hip fracture risk.<sup>46</sup> The Singaporean Chinese Health Study observed a significant dose-dependent inverse relationship between dietary vitamin B<sub>6</sub> intake and risk of hip fracture among women and not with men; the women were also further reported to have a history of diabetes.<sup>52</sup> Similarly, a small-sampled cross-sectional study reported that lower serum vitamin B<sub>6</sub>, folate and vitamin B<sub>12</sub> concentrations were significantly associated with lower serum concentrations of osteocalcin (OC), a bone turnover marker. Lower vitamin B<sub>6</sub> and folate concentrations were associated with lower trabecular thickness and trabecular area but there was no association between B vitamins and BMD or tartrate-resistant acid phosphatase (TRAP).<sup>28</sup>



TABLE 1 Observational studies on the association between B vitamins and bone health determinants and fracture risks

Reference	Sample size and subjects	Exposures and outcomes	Main findings
<i>Studies using blood (serum or plasma) samples</i>			
Cagnacci et al. <sup>21</sup>	161 Italian postmenopausal women	Serum folate, vitamin B <sub>12</sub> and total serum homocysteine/BMD	Folate was positively related to BMD ( $r = 0.254$ , $p < 0.011$ ) but not vitamin B <sub>12</sub> and homocysteine
Dhonukshe-Rutten et al. <sup>22</sup>	194 free-living Dutch frail elderly aged $\geq 70$ years	Serum or plasma vitamin B <sub>12</sub> /BMC and BMD	BMC and BMD were explained positively by plasma vitamin B <sub>12</sub> in women ( $R^2 = 1.3\%–3.1\%$ ). The risk of osteoporosis was more profound in women with marginal or deficient vitamin B <sub>12</sub> status compared to women with a normal status
Golbahar et al. <sup>23</sup>	271 Iranian postmenopausal women with mean age of 60.8 years	Plasma total homocysteine, plasma folate and vitamin B <sub>12</sub> ; MTHFR C667T polymorphism/femur and lumbar spine BMD	Lumbar spine BMD positively associated with plasma folate ( $r = 0.14$ , $p = 0.02$ ), no correlation observed between MTHFR, vitamin B <sub>12</sub> and femur and lumbar spine BMD. Negative correlation for the logarithm of plasma total homocysteine and femoral neck ( $r = -0.18$ , $p = 0.003$ ) and lumbar spine BMD ( $r = -0.16$ , $p = 0.01$ )
Golbahar et al. <sup>24</sup>	366 Iranian postmenopausal women with mean age of 60.8 years	RBC 5-MTHFR and plasma 5-MTHFR/BMD	RBC 5-MTHF was more positively correlated with BMD at the lumbar spine ( $r = 0.21$ , $p = 0.001$ ) and femoral neck ( $r = 0.19$ , $p = 0.004$ ) than was plasma 5-MTHF (lumbar spine; $r = 0.14$ , $p = 0.03$ and femoral neck; $r = 0.17$ , $p = 0.006$ )
Morris et al. <sup>25</sup>	1500 White American men and women aged $> 55$ years	Serum and RBC folate, serum vitamin B <sub>12</sub> and homocysteine/BMD; osteoporosis prevalence risk factor	Serum and RBC folate were not related to BMD or osteoporosis. Vitamin B <sub>12</sub> was positively associated ( $p = 0.01$ ) with BMD when B <sub>12</sub> $< 220$ (pmol L <sup>-1</sup> ). Significant risk of osteoporosis reported in the lowest quartile compared to the highest quartile. Individuals with serum Hcy $\geq 20$ $\mu\text{mol L}^{-1}$ had significantly lower BMD than subjects with serum Hcy $< 10$ $\mu\text{mol L}^{-1}$  Prevalence of osteoporosis marginally increased ( $p = 0.049$ ) among participants in the lowest serum vitamin B <sub>12</sub> quartile category
Baines et al. <sup>26</sup>	328 British postmenopausal women	Serum folate, vitamin B <sub>6</sub> , B <sub>12</sub> and MTHFR genotypes, and plasma	Folate was significantly positively associated with BMD ( $r = 0.132$ , $p = 0.025$ , log folate) but not vitamins B <sub>6</sub> , B <sub>12</sub> . Also, total Hcy appeared to be related to BMD

TABLE 1 (Continued)

Reference	Sample size and subjects	Exposures and outcomes	Main findings
		homocysteine/ BMD	( $r = -0.130, p = 0.033$ , log total Hcy)
Bozkurt et al. <sup>27</sup>	178 Turkish postmenopausal women with mean age $53.8 \pm 7.1$ years (range: 38–75 years)	Serum folate, B <sub>12</sub> and homocysteine/ BMD	High Hcy and low vitamin B <sub>12</sub> levels were associated with the risk of osteoporosis. Vitamin B <sub>12</sub> <quintile value ( $p < 0.05$ ) and the Hcy concentrations >median value ( $p < 0.05$ ) were the significant variables to predict osteoporosis in both the femur and the lumbar vertebra. No association was found between folate and BMD (femoral neck and lumbar spine)
Holstein et al. <sup>28</sup>	94 German men and women aged 52–83 years	Serum folate, B <sub>6</sub> and B <sub>12</sub> /BMD, trabecular thickness, number and area; BTMs, OC and TRAP	Significant lower trabecular thickness and trabecular area in subjects with low serum folate and vitamin B <sub>6</sub> concentrations ( $p < 0.05$ ). Osteocalcin concentrations was significantly lowered in subjects with a low serum B vitamin concentration ( $p < 0.05$ )
Haliloglu et al. <sup>29</sup>	120 Turkish postmenopausal women	Serum folate, vitamin B <sub>12</sub> and homocysteine/ BMD, BTM (BAP and CTx)	Serum Hcy concentrations were significantly higher in osteoporotic women after adjusting for confounders (adjusted OR = 38.95 [1.474–1029.88] $p = 0.02$ ). Serum homocysteine was positively related with BTM (CTx and BAP concentrations) $\beta = 0.239, p = 0.026; \beta = 0.451, p = 0.001$ . No association between folate and vitamin B <sub>12</sub> and BMD or BTM
Rumbak et al. <sup>30</sup>	131 Croatian women aged 45–65 years	Plasma homocysteine, serum and RBC folate, and vitamin B <sub>12</sub> /BMD	No relationship was found for homocysteine, folate or B <sub>12</sub> and BMD
Bailey et al. <sup>31</sup>	2806 US women aged $\geq 50$ years	Plasma total Hcy, methylmalonic acid, vitamin B <sub>12</sub> and serum/red blood cell folate/ total-body and lumbar spine BMD, BTM (BAP and uNTx)	High concentrations of MMA and total Hcy were related to increased lumbar osteoporosis risk. Total Hcy was negatively related, serum folate was positively associated, and MMA and vitamin B <sub>12</sub> were not significantly related with lumbar and total-body BMD
Tariq et al. <sup>32</sup>	156 postmenopausal women aged 50–70 years	Serum 25(OH)D, vitamin B <sub>12</sub> , tHCY and BMD	Significant negative correlation of homocysteine with vitamin D and B <sub>12</sub> in postmenopausal non-osteoporotic ( $r = -0.383, p = 0.005$ ) and homocysteine with vitamin B <sub>12</sub> in postmenopausal osteoporotic women ( $\rho = -0.376, p < 0.001$ )

(Continues)

TABLE 1 (Continued)

Reference	Sample size and subjects	Exposures and outcomes	Main findings
Beyazit and Pek <sup>33</sup>	184 Turkish postmenopausal women with average age $57.5 \pm 10.6$ years	Serum vitamin B <sub>12</sub> , folate, uric acid and inflammation markers/BMD	No association was found between concentrations of serum vitamin B <sub>12</sub> , folate and inflammatory markers with femur neck and lumbar spine BMD measurements. Higher tertiles of uric acid was observed with higher BMD values. There was a correlation between femoral neck BMD and uric acid ( $p < 0.001$ ) and BMI ( $p = 0.003$ )
Wang et al. <sup>34</sup>	1829 residents (men $\geq 50$ years and women $\geq 45$ years) of Shanghai, China	Serum vitamin B <sub>6</sub> / lumbar spine BMD, BTM (N-terminal propeptide of type I collagen, $\beta$ -C-terminal telopeptide of type I collagen and osteocalcin)	Osteoporosis risk was 61% higher only in women with serum vitamin B <sub>6</sub> concentrations of $< 19.2 \mu\text{g L}^{-1}$ than those with $> 26.9 \mu\text{g L}^{-1}$ (OR = 1.61, 95% CI = 1.00–2.58). Serum vitamin B <sub>6</sub> concentration was significantly negatively correlated to concentrations of all bone turnover markers in the osteoporotic women. No association was observed in men
Kalimeri et al. <sup>35</sup>	93 healthy Chinese-Singaporean postmenopausal women aged between 55 and 70 years old	Fasting plasma insulin, glucose, folate, and vitamin B <sub>12</sub> /area BMD (aBMD) and volumetric BMD (vBMD)	Folate concentrations were significantly higher among the normal BMD group compared to the osteoporosis group ( $p = 0.04$ ). The aBMD and vBMD were positively associated with folate concentrations, whereas composite strength indices were positively associated with vitamin B <sub>12</sub> concentrations ( $p < 0.05$ )
Liu et al. <sup>36</sup>	3529 members of 2 cohorts (ages 35–90 years; mean, 51 years)	Plasma vitamin B <sub>6</sub> , B <sub>12</sub> , folate and methylmalonic acid (MMA), a biomarker for vitamin B <sub>12</sub> /vBMD by DXA and QCT	There was an association between rs2274976 and vitamin B <sub>12</sub> and rs34671784 and MMA $< 210 \text{ nmol L}^{-1}$ and lumbar spine BMD. An association was also found between rs6586281 and vitamin B <sub>12</sub> $\geq 258 \text{ pmol L}^{-1}$ and femoral neck BMD
Saiedullah et al. <sup>37</sup>	77 postmenopausal women (age $> 45$ years)	Serum vitamin B <sub>12</sub> , BMD and T-scores	The log of vitamin B <sub>12</sub> was positively associated with BMD (0.119 [ $p = 0.018$ ], 0.085 [ $p = 0.140$ ], 0.011 [ $p = 0.012$ ]) and T-score (1.028 [ $p = 0.022$ ], 0.698 [ $p = 0.064$ ], 0.940 [ $p = 0.015$ ]) at lumbar spine, right and left femoral neck. As can be noted, the right femoral neck is not significant
<i>Studies using blood samples and dietary intakes</i>			
Clarke et al. <sup>38</sup>	110 treated celiac disease patients; mean age men 53.0 (12.3) and women 52.0 (12.7)	Dietary B vitamin intakes and Plasma vitamin B <sub>2</sub> , B <sub>6</sub> , B <sub>12</sub> and homocysteine, and	Serum vitamin B <sub>12</sub> (but no other B vitamin biomarker) was a significant determinant of BMD at the femoral neck ( $\beta = 0.416$ ,

TABLE 1 (Continued)

Reference	Sample size and subjects	Exposures and outcomes	Main findings
		serum 25-hydroxyvitamin D and BMD	$p = 0.011$ ) and total hip ( $\beta = 0.327$ , $p = 0.049$ ) in men only
<i>Studies using dietary intakes</i>			
Abrahamsen et al. <sup>39</sup>	1700 Danish postmenopausal women	Dietary intake of vitamin B <sub>2</sub> , B <sub>6</sub> , folate, and B <sub>12</sub> /BMD; fracture risk	Vitamin B <sub>2</sub> intake was significantly positively correlated with femoral neck BMD ( <i>TT</i> genotype women) ( $p < 0.05$ ). MTHFR genotype was associated with femoral neck and lumbar spine BMD in the lowest quartile of vitamin B <sub>2</sub> intake and similar threshold were observed for folate, vitamin B <sub>6</sub> and B <sub>12</sub>
Ilesanmi-Oyelere et al. <sup>40</sup>	101 New Zealand postmenopausal women aged between 54 and 81 years	Dietary vitamin B <sub>2</sub> and B <sub>3</sub> /BMD	Positive association was found between intake of vitamin B <sub>2</sub> and spine BMD ( $r = 0.232$ , $p = 0.020$ ) as well as B <sub>3</sub> and lumbar spine ( $r = 0.256$ , $p < 0.01$ ), femoral neck ( $r = 0.305$ , $p < 0.01$ ), hip ( $r = 0.257$ , $p < 0.01$ ) and whole-body BMD ( $r = 0.299$ , $p < 0.01$ )

Abbreviations: BAP, bone alkaline phosphatase; BMC, bone mineral content; BMD, bone mineral density; BTM, bone turnover markers; CI, confidence interval; CTX, C-terminal telopeptide; DXA, dual-energy X-ray absorptiometry; HCY, homocysteine; MMA, methylmalonic acid; MTHFR, methylenetetrahydrofolate reductase; OC, osteocalcin; OR, odds ratio; QCT, quantitative computed tomography; RBC, red blood cell; TRAP, tartrate-resistant acid phosphatase; uNTX, urinary N-telopeptide.

## FOLATE

A clinical trial reported by Herrmann et al.<sup>56</sup> showed that a combination of vitamin B<sub>6</sub>, B<sub>12</sub> and folate (vitamin B<sub>9</sub>) supplementation increased lumbar spine BMD, reduced HCY and decreased OC and P1NP only in hyperhomocysteinaemic patients. This may be as a result of the apparent effect and role of homocysteine on bone density and quality. Removal of tHcy from the circulation can either be by remethylation, which is catalysed by MTHFR, or by transsulfuration, catalysed by  $\beta$ -cystathionine synthase, which requires vitamin B<sub>6</sub> and both enzymes are regulated by *S*-adenosyl methionine and could result in the elevation of homocysteine if impaired because of their dependency on each other.<sup>48</sup>

Some years later, another randomised clinical trial led by Herrmann et al.<sup>59</sup> also reported a combination of vitamin D, folate, vitamin B<sub>12</sub>, B<sub>6</sub> and calcium carbonate increased 25(OH)D and lowered parathormone, bone alkaline phosphatase (BAP), OC and TRAP. Furthermore, the nurses' health study, however, reported that a high intake of vitamin B<sub>6</sub> ( $\geq 35$  mg day<sup>-1</sup>) was associated with increased risk of hip fracture in postmenopausal women.<sup>53</sup> Similar observation of a high dose of vitamin B<sub>6</sub> being somewhat associated with risk of hip fracture was also reported in a clinical trial by Garcia Lopez et al.<sup>64</sup> However, no association was found on the effect of B vitamins (vitamin B<sub>12</sub> and folate) in reducing

fracture risk or bone metabolism rates measured using bone biomarkers (CTX and P1NP) in an ancillary study of the Women's Antioxidant and Folic Acid Cardiovascular Study (WAFACS).<sup>63</sup> However, a significant interaction was found between vitamin B<sub>6</sub> treatment and fracture risk.

Observational study findings and reports on the effect of folate on BMD and risk of fractures have been inconsistent. Some epidemiological studies have reported a significant association between increased folate intake and/or level and increase in BMD/BTM<sup>21,23,26,28,31,35,39,47,50</sup> or reduced fracture risk.<sup>44,45,54</sup> Meanwhile, others have reported no associations.<sup>25,29,30,55</sup> More studies are required to evaluate the effect of folate on bone parameters especially conducted at different stages of the life span.

## COBALAMIN

Vitamin B<sub>12</sub> and bone health have been well researched in various community settings and ethnic groups, either singly or with other B vitamins. In this review, 17 cross-sectional studies reported on association of vitamin B<sub>12</sub> and bone mass.<sup>21–23,25–33,35–39</sup> Of these, eight studies found a significant association between vitamin B<sub>12</sub> and BMD.<sup>22,25,27,35–39</sup> There were 12 reporting longitudinal studies for vitamin B<sub>12</sub> and bone parameters,<sup>41–50,52,53</sup> with three of these studies reporting a relationship

TABLE 2 Longitudinal studies on the association between B vitamins and bone health determinants and fracture risks

Reference	Sample size and subjects	Exposures and outcomes	Main findings
<i>Studies using blood (serum or plasma) samples</i>			
Stone et al. <sup>41</sup>	83 White American women aged $\geq 65$ years/3.5 and 5.9 years follow-up	Serum vitamin B <sub>12</sub> /hip and calcaneal BMD measures; BTM (BAP and osteocalcin)	Women with serum vitamin B <sub>12</sub> concentrations $\leq 280$ pg mL <sup>-1</sup> experienced more hip bone loss than those with B <sub>12</sub> $> 280$ pg mL <sup>-1</sup> . No relationship was found between vitamin B <sub>12</sub> and BTM or calcaneal BMD.
Dhonukshe-Rutten et al. <sup>42</sup>	615 men and 652 women with a mean age of $76 \pm 6.6$ (SD) years/3 years follow-up	Plasma Hcy, serum vitamin B <sub>12</sub> and the combined effect/BUA, BTM (OC and DPD/Cr) and fracture risk	Women with vitamin B <sub>12</sub> concentrations $< 200$ pM and Hcy concentrations $> 15$ $\mu$ M had lower BUA, higher DPD/Cr and higher OC concentrations. With high Hcy and/or low vitamin B <sub>12</sub> concentrations, the risk of fracture was 3.8 for men and 2.8 for women. Both vitamin B <sub>12</sub> and Hcy was associated with bone health ( $p < 0.05$ )
Tucker et al. <sup>43</sup>	2576 White American men and women aged 30–87 years/cross-sectional analysis	Plasma vitamin B <sub>12</sub> /BMD at all sites	Both men and women with vitamin B <sub>12</sub> concentrations $< 148$ pM had lower than average BMD than those with vitamin B <sub>12</sub> above this cut-off mark. These were significant for men at the hip and women at the spine ( $p < 0.05$ )
Ravaglia et al. <sup>44</sup>	702 Italians aged 65–94 years/4 years follow-up	Serum folate, vitamin B <sub>12</sub> and plasma total Hcy/fracture risks	Hyperhomocysteinaemia (plasma total homocysteine [total Hcy] $> 15$ $\mu$ M) was 1.58 (95% CI = 0.71–3.53) and low folate concentrations was related to increased risk of fractures. No association for serum vitamin B <sub>12</sub>
Gjesdal et al. <sup>45</sup>	4766 Norwegian men and women aged 65–67 years/12.6 years follow-up	Plasma total Hcy, folate, and vitamin B <sub>12</sub> and MTHFR 677 C→T and 1298 C→T polymorphisms/hip fracture	Dose–response analyses showed a positive association between total Hcy and risk of fracture in both sexes and a negative association between folate and risk of fracture in women. Adjusted hazard ratio at 95% confidence interval for fracture in subjects with high ( $\geq 15$ $\mu$ M) compared to low concentrations ( $< 9.0$ $\mu$ M) of total Hcy was 2.42 (1.43–4.09) among women and 1.37 (0.63–2.98) among men. No significant association between vitamin B <sub>12</sub> concentrations of MTHFR genotype and hip fracture risk
McLean et al. <sup>46</sup>	1002 White American men and women with mean aged 75 years/4 years follow-up	Plasma folate, vitamin B <sub>12</sub> , vitamin B <sub>6</sub> and homocysteine/BMD, fracture risk	An inverse association was observed between vitamin B <sub>6</sub> and bone loss ( $p$ for trend 0.01). Vitamin B <sub>6</sub> and B <sub>12</sub> were inversely related to hip fracture risk even after adjusting for BMD and homocysteine (all $p$ for trend $< 0.05$ )
Cagnacci et al. <sup>47</sup>	161 healthy postmenopausal women mean aged 54 years/5 years follow-up	Serum folate, vitamin B <sub>12</sub> and homocysteine/BMD	Follow-up assessments at baseline and 5-year follow-up showed a significant relationship between serum folate and annual change of lumbar spine BMD, that is, folate concentrations (the coefficient of regression [CR] = 2.040; 95% CI = 0.483–3.596; $p = 0.011$ ) and the initial BMD values (CR = $-0.060$ ; 95% CI = $-0.117$ to $-0.003$ ; $p = 0.040$ ). No significant relation between the change of vertebral BMD and homocysteine or vitamin B <sub>12</sub> was found



TABLE 2 (Continued)

Reference	Sample size and subjects	Exposures and outcomes	Main findings
<i>Studies using dietary intakes</i>			
Macdonald et al. <sup>48</sup>	1241 Scottish women aged 45–54 years/6.6 years follow-up	Dietary intake of vitamin B <sub>2</sub> , B <sub>6</sub> , folate and B <sub>12</sub> /BMD, BMD change; fPYD/Cr and fDPD/Cr (nmol/mmol) and serum P1NP	Intake of vitamin B <sub>2</sub> was significantly positively associated with MTHFR <i>TT</i> genotype, and BMD ( $p = 0.01$ for baseline FN BMD, $p = 0.02$ for follow-up FN BMD). No association was observed between MTHFR ( <i>CC</i> or <i>CT</i> ) genotype or other B vitamins and BMD
Yazdanpanah et al. <sup>49</sup>	5304 Dutch men and women aged $\geq 55$ years/ $\geq 6$ –7 years follow-up	Dietary intake of vitamin B <sub>2</sub> , B <sub>6</sub> , folate and B <sub>12</sub> /BMD and fracture risks	A positive relationship was observed between vitamin B <sub>2</sub> , B <sub>6</sub> and femoral neck BMD and an inverse relationship between B-6 and fracture risks ( $p < 0.05$ ). However, no association was found between folate, B <sub>12</sub> and bone
Rejnmark et al. <sup>50</sup>	1869 Danish perimenopausal women aged 43–58 years/10 years follow-up	Dietary and supplemented intake of vitamin B <sub>2</sub> , B <sub>12</sub> , and folate/BMD, fracture risk	Diet and supplement intake of folate was positively correlated with femoral neck BMD at year 5 ( $p < 0.05$ ). No associations were found between intake of vitamin B <sub>2</sub> or B <sub>12</sub> and BMD or fracture risk
Yazdanpanah et al. <sup>51</sup>	5035 Dutch men and women aged $\geq 55$ years/ $\geq 6$ –7 years follow-up	Dietary intake of vitamin B <sub>2</sub> and folate/BMD, fracture risk	A small significant positive association was found between dietary pyridoxine ( $\beta = 0.09$ , $p = 1 \times 10^{-8}$ ) and riboflavin intake ( $\beta = 0.06$ , $p = 0.002$ ) with baseline femoral neck BMD. Lowest quartile of vitamin B <sub>2</sub> intake in female 677-T homozygotes had 1.8 times higher risk for incident osteoporotic fractures and 2.6 times higher risk for fragility fractures compared to the 677-CC genotype. In the lowest quartile of B <sub>2</sub> intake, T-homozygous individuals (men and women combined) had higher Hcy concentrations compared to C-homozygotes. No association was found for dietary folate
Dai et al. <sup>52</sup>	63,154 Singaporean Chinese men and women aged 45–74 years/5 years follow-up	Dietary intake of vitamin B <sub>1</sub> , B <sub>2</sub> , B <sub>3</sub> , B <sub>6</sub> , B <sub>12</sub> and folate/hip fracture risk	A significant inverse relationship between dietary B <sub>6</sub> intake and hip fracture risk was observed among women ( $p$ for trend = 0.002) but not among men. 22% reduction in hip fracture risk was observed with the highest quartile intake of B <sub>6</sub> . No association was observed with the other B vitamins
Meyer et al. <sup>53</sup>	75,864 postmenopausal women	Dietary and plasma vitamin B <sub>6</sub> and B <sub>12</sub> , hip fracture	High intake of both vitamin B <sub>6</sub> ( $\geq 35$ mg day <sup>-1</sup> ), ( $p = 0.06$ for linear trend) and B <sub>12</sub> ( $\geq 30$ $\mu$ g day <sup>-1</sup> ), ( $p = 0.02$ for linear trend) were associated with increased fracture risk

Abbreviations: BAP, bone alkaline phosphatase; BMD, bone mineral density; BTM, bone turnover marker; BUA, broadband ultrasound attenuation; Cr, creatinine; DPD, deoxyypyridinoline; HCY, homocysteine; MTHFR, methylenetetrahydrofolate reductase; OC, osteocalcin; PYD, pyridinoline; P1NP, procollagen-1 N-terminal peptide.

between vitamin B<sub>12</sub> and BMD,<sup>41,43,48</sup> one study on bone turnover markers<sup>42</sup> and another one on hip fracture.<sup>46</sup> In total, nine intervention studies were reviewed for vitamin B<sub>12</sub> and bone,<sup>56–64</sup> with three of these studies reporting a significant effect of vitamin B<sub>12</sub> on bone with respect to supporting the protective role of vitamin B<sub>12</sub>; one finding

was noted in hyperhomocysteinaemic patients,<sup>56</sup> another study reported an effect on bone turnover markers<sup>59</sup> and another study reported an effect on fracture risk in persons aged  $\geq 80$  years.<sup>62</sup> Even though not many intervention study reports showed a significant effect, supplementation with B vitamins reduced tHCY

TABLE 3 Randomised clinical trials on B vitamins and bone health outcomes

Reference	Sample size and subjects	Treatment (T) and control (C)	Outcomes	Main findings
Sato et al. <sup>54</sup>	628 aged $\geq 65$ years stroke patients with residual hemiplegia; follow-up for 1 year + /2 years	T: Daily oral treatment with 5 mg of folate and 1500 $\mu\text{g}$ of mecobalamin for 2 years. C: double placebo	Plasma homocysteine and incidence of hip fracture	Treatment group had decreased plasma homocysteine concentrations and placebo group had higher homocysteine after 2 years ( $p < 0.001$ ). Treatment group also had significantly reduced incidence of fracture than placebo group ( $p < 0.001$ ). No difference was observed in BMD
Herrmann et al. <sup>55</sup>	61 healthy individuals (mean age: 58+/-8 years); 8 weeks follow-up	T: 0.4, 1 or 5 mg of folate daily C: Placebo	Fasting serum HCY, folate, vitamin B <sub>12</sub> and BTM-osteocalcin (OC), procollagen type I N-terminal propeptide (PINP) and C-terminal telopeptides of human collagen type I (CTX-I)	No effect was found for folate supplementation on bone turnover markers
Herrmann et al. <sup>56</sup>	47 osteoporotic subjects (age 55–82 years); 4, 8 and 12 months follow-up	T: 2.5 mg folate, 0.5 mg vitamin B <sub>12</sub> and 25 mg vitamin B <sub>6</sub> C: Placebo	BMD, urinary DPD and plasma TRAP, CTx, OC and PINP	B vitamin supplementation had no effect on BMD, TRAP, CTx, OC and PINP. However, B vitamin supplementation significantly reduced HCY, it also increased lumbar spine BMD and decreased OC and PINP in hyperhomocysteinaemic subjects
Green et al. <sup>57</sup>	276 Healthy older persons aged $\geq 65$ years; follow-up for 2 years	T: Daily supplement of folate (1 mg), vitamin B <sub>12</sub> (500 $\mu\text{g}$ ), and vitamin B <sub>6</sub> (10 mg) C: Placebo	Plasma homocysteine, serum bone-specific alkaline phosphatase, bone-derived collagen fragments ( $\beta$ -CTX)	Folate, vitamin B <sub>6</sub> and B <sub>12</sub> supplementation lowered plasma homocysteine (95% CI: 3.9, 6.6 $\mu\text{mol L}^{-1}$ ; $p < 0.001$ ) but had no effect on bone turnover markers
Shahab-Ferdows et al. <sup>58</sup>	132 non-pregnant and non-lactating women aged 20–59 years; 3 months follow-up	T: 1 mg of vitamin B <sub>12</sub> i.m. followed by 500 $\mu\text{g}$ /day oral vitamin B <sub>12</sub> supplements C: Placebo	Serum B <sub>12</sub> , folate, holotranscobalamin (holoTC), total homocysteine, MMA; BTM: BAP	Vitamin B <sub>12</sub> supplementation increased holoTC ( $r = 0.7$ ; $p < 0.001$ ), serum vitamin B <sub>12</sub> and lowered MMA ( $r = -0.28$ , $p < 0.0007$ ) and total Hcy concentrations ( $r = -0.20$ , $p < 0.01$ ). No effect on BAP was found
Herrmann et al. <sup>59</sup>	93 healthy subjects; age $> 54$ years; 6 and 12 months follow-up	T: Daily vitamin D <sub>3</sub> (1200 IU), folic acid (0.5 mg), vitamin B <sub>12</sub> (0.5 mg), vitamin B <sub>6</sub> (50 mg), and calcium carbonate (456 mg) (group A) or only vitamin D <sub>3</sub> plus calcium carbonate (group B)	Parathormone, plasma 25-hydroxy vitamin D, bone alkaline phosphatase, sclerostin, TRAP, OC	One year supplementation of vitamin D <sub>3</sub> or D <sub>3</sub> and B increased plasma 25(OH)D, lowered parathormone and decreased BAP, OC and TRAP. Low tHCY had no additional effect on bone turnover
Keser et al. <sup>60</sup>	31 women aged 65–93 years with homocysteine concentrations $>10 \mu\text{mol L}^{-1}$ ; 4 months follow-up	T: Daily folic acid (800 $\mu\text{g}$ ) and vitamin B <sub>12</sub> (1000 $\mu\text{g}$ ) C: Matching placebo	Serum homocysteine, alkaline phosphatase, and CTX-I	Homocysteine concentrations was lower in the treatment group compared to the placebo (10.6 vs 18.5 $\mu\text{mol L}^{-1}$ , $p = 0.007$ ) but there was no difference in the alkaline phosphatase or CTX-I

TABLE 3 (Continued)

Reference	Sample size and subjects	Treatment (T) and control (C)	Outcomes	Main findings
Gommans et al. <sup>61</sup>	8164 Caucasian with recent stroke or transient ischaemic attack; median duration of 2.8 years therapy and 3.4 years follow-up	T: One tablet of folic acid 2 mg, vitamin B <sub>6</sub> 25 mg, vitamin B <sub>12</sub> 500 µg daily C: One tablet of placebo	Serum homocysteine, osteoporotic or osteoporotic hip fracture risks	There was no effect with daily treatment with B vitamins on osteoporotic fractures. Homocysteine concentrations was lower in the treatment group but did not predict fracture risks
van Wijngaarden et al. <sup>62</sup>	2919 individuals aged ≥ 65 years with elevated homocysteine concentrations (12–50 µmol L <sup>-1</sup> ); 2 years follow-up	T: Daily 500 µg vitamin B <sub>12</sub> plus 400 µg folic acid plus 600 IU vitamin D <sub>3</sub> supplementation C: Placebo plus 600 IU vitamin D <sub>3</sub>	Serum homocysteine, First time osteoporotic fracture	Homocysteine concentrations was lower in the treatment group, but fracture risk did not differ between groups. In persons aged ≥ 80 years, fracture risk was lower in the treatment group. However, incidence of cancer was higher in the treatment group than the placebo
Stone et al. <sup>63</sup>	8171 participants aged ≥ 40 years; 7.3 years treatment and follow-up	T: folic acid (2.5 mg day <sup>-1</sup> ), vitamin B <sub>6</sub> (50 mg day <sup>-1</sup> ), and vitamin B <sub>12</sub> (1 mg day <sup>-1</sup> ) C: Placebo	Plasma concentrations of homocysteine and B vitamins, BTM-CTX-I and P1NP and fracture risks (wrist, hip and non-spine fractures)	No significant difference was found for any effect of supplementation with B vitamins in reducing fracture risks or bone metabolism rates
Garcia Lopez et al. <sup>64</sup>	6837 participants from 2 RCTs (mean age was 62.3 ± 11.0 years); 3.4 years follow-up for Norwegian Vitamin Trial (NORVIT) and 3.2 years for Western Norway B Vitamin Intervention Trial (WENBIT)	T <sup>1</sup> : folic acid (0.8 mg) plus vitamin B <sub>12</sub> (0.4 mg) and vitamin B <sub>6</sub> (40 mg) <sup>2</sup> ; folic acid (0.8 mg) plus vitamin B <sub>12</sub> (0.4 mg) <sup>3</sup> ; vitamin B <sub>6</sub> alone (40 mg) C: Placebo	Plasma tHcy and vitamin B <sub>6</sub> , Serum folate and vitamin B <sub>12</sub> . Hip fracture risks	Treatment with folate plus vitamin B <sub>12</sub> was not associated with hip fracture risk however, treatment with high dose of vitamin B <sub>6</sub> was slightly associated with risk of hip fracture (HR = 1.42; 95% CI = 1.09–1.83).

Abbreviations: BAP, bone alkaline phosphatase; BMD, bone mineral density; BTM, bone turnover marker; CI, confidence interval; CTX-1, type I collagen cross-linked C-telopeptide; DPD, deoxyripyridinoline; HCY, homocysteine; holoTC, holotranscobalamin; HR, hazard ratio; MMA, methylmalonic acid; OC, osteocalcin; P1NP, procollagen-1 N-terminal peptide; TRAP, tartrate-resistant acid phosphatase.

TABLE 4 Meta-analyses on B vitamins and bone health outcomes

Reference	Sample size and subjects	Treatment (T) and control (C)	Outcomes	Main findings
Van Wijngaarden et al. <sup>65</sup>	14 cross sectional studies, 13 prospective observational studies and 1 RCT	Folate, vitamin B <sub>12</sub> and homocysteine	BMD and fracture risk	There was a 4% decrease in fracture risk per 50 pmol L <sup>-1</sup> increase in vitamin B <sub>12</sub> concentrations, which was borderline significant. There was also a 4% increase in fracture risk per µmol L <sup>-1</sup> increase in homocysteine concentration. No conclusion for folate as a result of too few studies
Ruan et al. <sup>66</sup>	8 RCTs	B vitamins and homocysteine	BTM and fracture risk	No risk-reducing effect of daily supplementation with B vitamins on bone turnover markers and osteoporotic fracture

Abbreviations: BMD, bone mineral density; BTM, bone turnover marker; RCT, randomised controlled trial.

concentrations in the subjects. This was evident in eight of the studies<sup>54,56–62</sup> showing high dependency of the metabolism of homocysteine on vitamin B<sub>12</sub>, folic acid and vitamin B<sub>6</sub>. Included among the factors that raise concentrations of homocysteine are a poor diet and lifestyle (high consumption of coffee, alcohol, and smoking), prescription medications (such as PPIs), poor thyroid function, diabetes, and rheumatoid arthritis.

Two systematic meta-analyses have been conducted on B vitamins and its effect on BMD, BTM and fracture risks. One of the meta-analyses reviewed 14 cross-sectional and 13 longitudinal studies and found a 4% decrease in fracture risk per 50 pmol L<sup>-1</sup> increase in vitamin B<sub>12</sub> concentrations, which was borderline significant; no significant effect was found on the relationship between vitamin B<sub>12</sub> and BMD. The other study found no risk reducing effect of daily supplementation of B vitamins on BTM and fracture risks. However, taken together, these results show a possible modest effect of B vitamins on bone quality, although more clinical studies are required to validate this effect.

## CONCLUSIONS

Based on the current available data, there are effects of vitamin B<sub>6</sub>, folate and vitamin B<sub>12</sub> on bone metabolism and bone physiology. However, more longitudinal studies and clinical intervention studies are required for both the dietary effects and supplementation effects of B vitamins on bone density and turnover. This is particularly important for the B vitamins that are less studied.

## AUTHOR CONTRIBUTIONS

Bolaji L. Ilesanmi-Oyelere conducted the search and wrote the first draft. Marlana C. Kruger reviewed the manuscript. Both authors read and approved the final version of the manuscript submitted for publication.

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## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

## DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article because no datasets were generated or analysed during the present study.

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## PEER REVIEW

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# Quality of life and home parenteral nutrition: a survey of UK healthcare professionals' knowledge, practice and opinions

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## Abstract

**Background:** There is increasing interest in the assessment of health-related quality of life (QoL) in the care of patients treated with home parenteral nutrition (HPN). However, it is not known whether healthcare professionals (HCPs) have embedded QoL assessment into routine clinical practice in line with current guidelines to favour a more holistic approach to HPN care. The aim of this study was to assess knowledge, current practice and the opinions of HCPs regarding QoL in care of patients on HPN.

**Methods:** An online survey was distributed via email to HCPs working with HPN patients throughout England, Scotland, Wales and Northern Ireland. Participants were identified using a mailing list for the British Intestinal Failure Alliance, a specialist group within the British Association for Parenteral and Enteral Nutrition.

**Results:** The survey was completed by 67 professionals comprising 24 dietitians, 17 nurses, 14 gastroenterologists, 6 pharmacists, 5 surgeons and 1 psychologist. Of these, 54 (80%) participants agreed that the measurement of QoL is useful. In contrast, 38 (57%) of all participants, including 27 (50%) of those participants who agreed that the measurement of QoL was useful, never measured QoL. Knowledge of QoL literature was rated as poor or very poor by 27 (40%) participants.

**Conclusions:** Despite the perceived usefulness and importance of QoL assessment, very few HCPs embed it into clinical practice. Knowledge of QoL literature and QoL tools is variable, and there is significant variability in QoL practice. This is clear in terms of the frequency of QoL assessments and heterogeneity in methodology. In contrast, there was almost unanimous agreement that the complications associated with HPN contribute to poorer QoL. There is a need for specific, evidence-based, clinical practice guidelines detailing how to define and measure QoL in this patient population.

## KEYWORDS

adults, home parenteral nutrition, intestinal failure, quality of life, survey

## Key points

- There is significant variability in quality-of-life (QoL) practice for patients treated with home parenteral nutrition (HPN).
- Our findings suggest that very few healthcare professionals are embedding QoL assessment into clinical practice.

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- Evidently, there appears to be a need for specific, evidence-based, clinical practice guidelines detailing how to define and measure QoL in HPN patients.

## INTRODUCTION

Home parenteral nutrition (HPN) is the primary life-saving therapy for patients with intestinal failure (IF) who cannot meet their nutritional requirements through the oral or enteral route and who are able to receive the therapy outside an acute clinical care setting.<sup>1</sup> HPN may be required for months to years and, in some cases, is required throughout life. The aims of the treatment are to increase survival and to improve the quality of life (QoL) of the patient.<sup>2</sup> However, HPN radically changes a person's life. It is time consuming and invasive. Patients struggle with ongoing symptoms of their underlying condition, live with multiple health problems and consequently are required to manage a range of drug and lifestyle management regimens. This inevitably has severe consequences for their QoL, with the most frequent issues including emotional function, fatigue and gastrointestinal symptoms.<sup>3</sup> Poorer QoL is found in patients on a higher number of HPN infusions per week and larger volume HPN and in those with less than 50 cm of remaining small bowel.<sup>4</sup>

QoL is a multidimensional concept that refers to 'an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations and standards'.<sup>5</sup> Assessing the QoL of patients treated with HPN provides the opportunity to evaluate response to treatment, can facilitate communication between the patient and healthcare professionals (HCPs) and can help to identify patient preferences.<sup>6</sup> Furthermore, QoL has been identified as the third most important outcome indicator that is essential for good quality of care in benign HPN care in two multicentre, international studies. The first study was based on the opinions of HCPs who specialise in HPN, who identified incidence of catheter-related bloodstream infections, incidence of rehospitalisations and QoL as quality indicators.<sup>1</sup> The second study was based on the opinions of patients treated with HPN. Their top three desired outcomes were incidence of catheter-related infection, survival and QoL.<sup>7</sup> Consequently, current European guidelines recommend that 'QoL should be used as criteria to assess the quality of care of HPN program'<sup>2</sup> and 'QoL for HPN patients be regularly measured using validated tools as part of standard clinical care'.<sup>8</sup> However, little is known as to whether HCPs have embedded QoL assessment into routine clinical practice, the frequency of these assessments and the instruments of choice. Previous studies of HCPs using QoL assessments have focussed on doctors who do not specialise in HPN. For example, a study

exploring knowledge and perception of the importance of health-related QoL among medical and surgical physicians found that only 38% of respondents were aware of QoL literature and used the results in clinical practice or for research purposes.<sup>9</sup> In a survey of oncologists from a large Canadian cancer care centre, 57% of participants felt that decisions were more difficult when they considered QoL issues, and despite 87% reporting QoL studies were useful for patient care, 69% reported that they would be more likely to base recommendations on experience rather than published literature.<sup>10</sup>

Consequently, the first aim of this study was to assess knowledge of QoL tools and the currently published literature on assessing QoL for patients receiving HPN. The second aim was to investigate the extent of QoL assessment in clinical practice among HCPs within multidisciplinary teams with responsibility for HPN patients. In particular, we sought to understand why QoL is being measured, which instruments are being utilised and the reasons for those choices. Our final aim was to understand the opinions of HCPs on the contributors to poor QoL and perceived importance of QoL assessment in clinical practice.

## METHODS

An online survey was developed specifically for this study. Prior to implementation, a working group of HPN specialists was asked to pilot the survey and score it out of 10 for ease of completion and clarity. This allowed a realistic estimate of time to complete. A small number of ambiguities were highlighted, which were corrected prior to implementation. The final survey, which is available in the supplementary material, was uploaded to the Crowdsignal platform ([www.crowdsignal.com](http://www.crowdsignal.com), accessed on 7 October 2021) and was open for 1 month. Crowdsignal is an online tool that can be used to create polls, surveys and quizzes. Responses are secure, and it is available free of charge or via a monthly or annual subscription, depending on user requirements. HCPs throughout England, Scotland, Wales and Northern Ireland and with responsibility for care of adult patients receiving HPN were invited to participate via an email. Non-HCPs and HCPs from outside of the United Kingdom were not eligible to participate. Participants were identified using a mailing list for the British Intestinal Failure Alliance (BIFA), which is a specialist group within the British Association for Parenteral and Enteral Nutrition and likely represents the majority of

HCPs involved in the delivery of HPN. The email contained study information and a survey link. The link was printed in a newsletter produced by the Parenteral and Enteral Nutrition Group of the British Dietetic Association and was also shared via the social media site Twitter. As responses were anonymous and did not include patient data, the Hampshire Research and Ethics Committee advised that ethical approval was not required.

The four key focus areas for data collection were demographics, current practice, knowledge and opinions (Figure 1). The survey contained 14 Likert scale questions, 12 categorical questions and an 'additional comments' box at the end of the survey. There were also opportunities to write additional comments at the end of each closed question.

## Statistical analysis

Results were exported from Crowdsignal to Microsoft Excel and copied to Stata SE 17 statistical analysis software. A descriptive data analysis was performed to establish frequencies and proportions, and Fisher's exact test was used to investigate differences between professions, centres or lengths of experience. Due to the small number of responses from certain centres, HPN centres (centres providing parenteral nutrition care to patients at home), IF centres (those providing support to inpatient surgical patients) and 'other' centres (hospitals not categorised as IF or HPN centres but that have responsibility for patients treated with HPN, for

example, a patient's local hospital) were grouped together. A  $p$ -value of  $<0.05$  was considered statistically significant.

## RESULTS

### Demographics

The survey was completed by 67 HCPs. Their characteristics are summarised in Table 1.

### Sample representation

To assess sample representation, each of the 23 centres providing HPN care in the United Kingdom was contacted to establish how many HCPs could have potentially participated in the survey, and from these responses, it was estimated that 41% of eligible participants completed the survey. With the exception of dietitians of whom 65% participated, this equates to approximately one-third of each individual speciality, with 34% of potential gastroenterologists, 30% of pharmacists, 34% of nurses, 42% of colorectal surgeons and 33% of psychologists participating.

### Knowledge

The HPN-QoL tool<sup>11</sup> was known to 23% of participants and was the most familiar tool among HCPs. This was

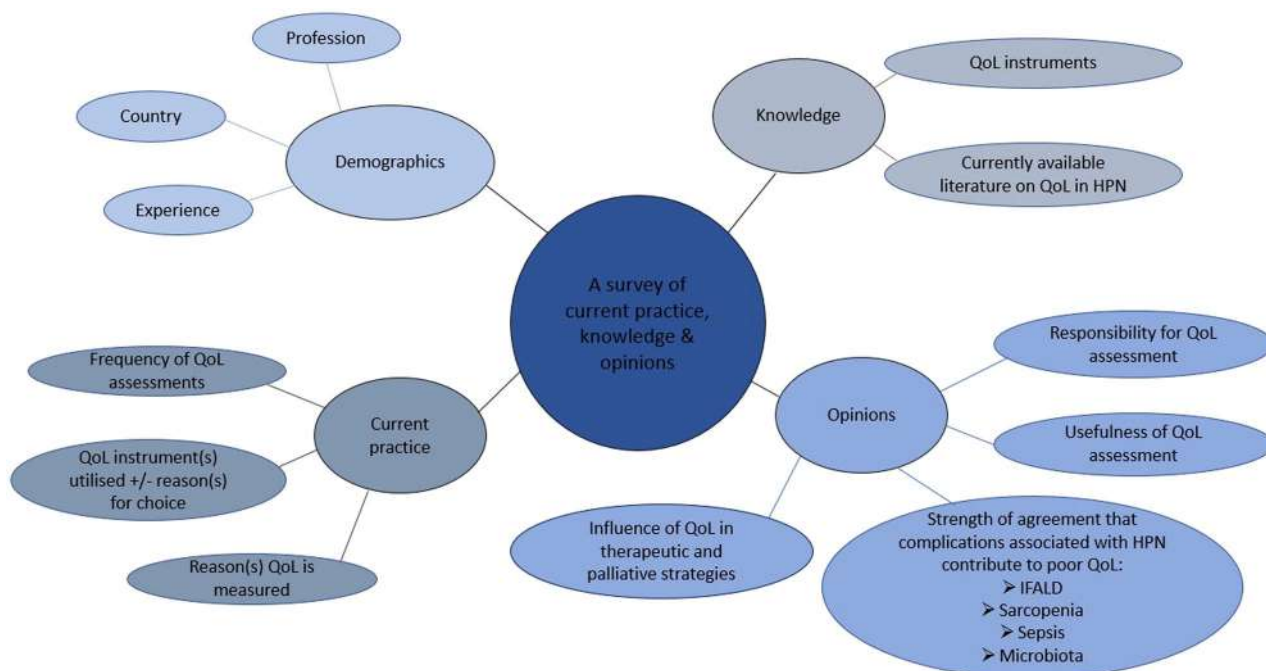


FIGURE 1 Conceptual diagram showing the four key areas of data collection



TABLE 1 Demographics of survey participants

	N (%)
<i>Country of workplace</i>	
England	53 (79)
Scotland	7 (10)
Northern Ireland	4 (6)
Wales	3 (4)
<i>Type of centre</i>	
Integrated HPN and IF centre	46 (69)
HPN centre	7 (10)
IF centre	3 (4)
Other	11 (16)
<i>Profession</i>	
Dietitian	24 (36)
Nurse	17 (25)
Gastroenterologist	14 (21)
Pharmacist	6 (9)
Colorectal surgeon	5 (7)
Psychologist	1 (2)
<i>Years of experience of working with HPN patients</i>	
<5	14 (21)
5–10	14 (21)
10–15	15 (23)
15–20	9 (14)
>20	14 (21)

Notes: Integrated HPN and IF centres provide parenteral nutrition care to patients at home and support to inpatient surgical patients. HPN centres provide parenteral nutrition care to patients at home. Intestinal failure centres provide support to inpatient surgical patients, and 'other' centres are hospitals not categorised as intestinal failure or HPN centres but that have responsibility for patients treated with HPN, for example, a patient's local hospital.

Abbreviations: HPN, home parenteral nutrition; IF, intestinal failure.

followed by the Short Form-36 (SF-36) (17%),<sup>12</sup> parenteral nutrition impact questionnaire (PNIQ) (14%),<sup>13</sup> EuroQoL-5 Dimension (EQ-5D) (12%),<sup>14</sup> short bowel syndrome QoL (SBS-QoL) (11%),<sup>15</sup> HPN patient-reported outcomes questionnaire (HPN-PROQ) (8%)<sup>16</sup> and New-QoL questionnaire.<sup>17</sup> Other tools reported included the distress thermometer (1%),<sup>18</sup> Hospital anxiety and depression scale score (1%)<sup>19</sup> and Multi-dimensional Scale of Perceived Social Support (1%).<sup>20</sup> However, 11% of participants reported having knowledge of none of the tools. In terms of the currently available literature on QoL in HPN, 40% of participants reported having 'poor' or 'very poor' knowledge, 39% 'fair' knowledge and only 20% 'good' or 'very good'.

Those with more experience (>20 years) were more likely to have knowledge of the SF-36<sup>12</sup> than those with five or fewer years of experience ( $p = 0.005$ ), and gastroenterologists were more familiar with SF-36 than dietitians and nurses ( $p = 0.015$ ).

## Current practice

More than half of the participants (57%) reported that QoL was never measured in their patients; 14% said it was measured  $\leq 3$  years, 6% every 2 years and 6% annually; and 14% of respondents were unsure. When the responses were separated by type of centre, 50% of participants from integrated IF/HPN centres and 86% of participants from HPN centres never measured QoL. Similarly, when the results were separated by participants who thought the measurement of QoL was useful, 50% reported never measuring QoL.

The HPN-QoL<sup>11</sup> instrument was the most frequently used tool, being chosen by 40% of the participants who measure QoL. This was followed by the SF-36<sup>12</sup> and EQ-5D,<sup>21</sup> each used by 14% of those who measured QoL: 12% of these HCPs opted for the SBS-QoL questionnaire,<sup>15</sup> 10% chose the PNIQ,<sup>13</sup> 2% used the HPN-PROQ<sup>16</sup> and 16% reported 'other' surveys such as the distress thermometer.<sup>18</sup>

The two most selected reasons for choosing a particular QoL instrument were the tool was an established unit of practice (36%) and familiarity (31%). Less popular reasons were ease of use (11%) and the instrument being part of a study (8%). However, 14% of HCPs were unsure why a QoL measure was chosen and no participants made a choice based on patient preferences. In terms of how the results of QoL assessments are shared, 29% of HCPs share with the wider clinical team, 26% disseminate the results at conferences, 12% share with patients, 12% publish in journals, 12% do not share results at all and 7% were unsure.

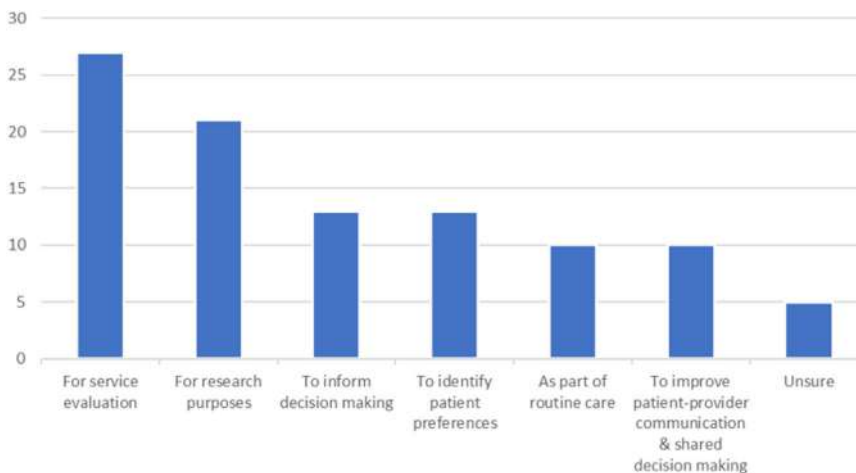
The reasons for measuring QoL were for service evaluation (27%); for research (21%); to inform decision-making (13%); to identify patient preferences and to help clinicians to make informed decisions (13%), because it is part of routine clinical care (10%); and to improve patient-provider communication and shared decision-making (10%). A few participants (5%) were unsure why QoL is measured (Figure 2).

## Opinions

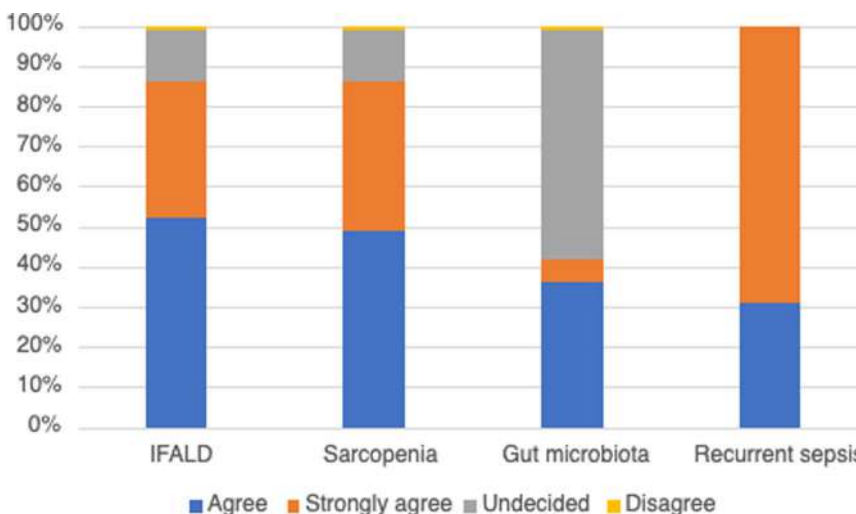
The majority of respondents (86%) agreed or strongly agreed that IF-associated liver disease (IFALD) and sarcopenia are contributors to poor QoL, whereas 13% were undecided about both complications and only 1% disagreed. There was little consistency in opinions about the role of the gut microbiota, with 57% of participants undecided as to whether the gut microbiota impacts



**FIGURE 2** The reasons for measuring quality of life (QoL) (%). Respondents could give more than one answer to this question.



**FIGURE 3** Strength of agreement that complications associated with home parenteral nutrition (HPN) contribute to poor quality of life (QoL) (%)



QoL; 42% agreed or strongly agreed, and 1% disagreed. All participants agreed or strongly agreed that recurrent sepsis is a contributor to poor QoL (Figure 3).

When asked about the role of QoL in HPN treatment, 86% of participants agreed or strongly agreed that QoL should influence therapeutic strategies. Similarly, 81% and 91% of participants agreed or strongly agreed that QoL should influence the decision to commence HPN and palliative HPN, respectively. A minority (16%) of participants were undecided about the role of QoL in making a decision to commence HPN, and 8% were undecided about palliative HPN (Figure 4).

Eighty per cent of participants agreed or strongly agreed that the measurement of QoL in HPN patients is useful, and 20% were undecided. Additional comments to all survey questions are available in Supporting Information, Appendix 1.

When asked whether more expensive treatment options should be considered if they improved QoL, 64% of participants agreed or strongly agreed, and 33% were undecided. The majority (75%) of participants agreed or strongly agreed that QoL assessments facilitate

patient–clinician communication, whereas 22% were undecided and 3% disagreed. When asked whether the idea of QoL is flawed, those variables are very difficult for the clinician to analyse, to control and therefore to integrate into clinical decision-making, 26% of participants agreed or strongly agreed, 28% were undecided and 44% disagreed or strongly disagreed (Figure 5).

For the different centre types, 98% of participants from integrated IF/HPN centres compared with 67% of participants from the other centres (HPN, IF, ‘other’) combined ( $p = 0.017$ ) agreed or strongly agreed that QoL should influence the decision to commence palliative HPN.

## DISCUSSION

To our knowledge, the present study is the first survey to investigate knowledge, practice and the opinions of HCPs with regard to QoL and HPN. There was consensus that the measurement of QoL in HPN patients is useful, suggesting it can be used to inform clinical

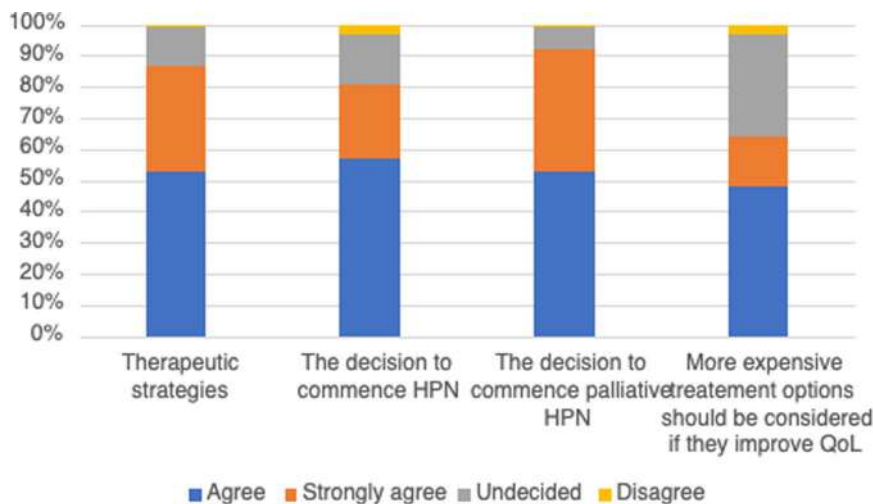


FIGURE 4 Strength of agreement that quality of life (QoL) should influence home parenteral nutrition (HPN) therapy (%)

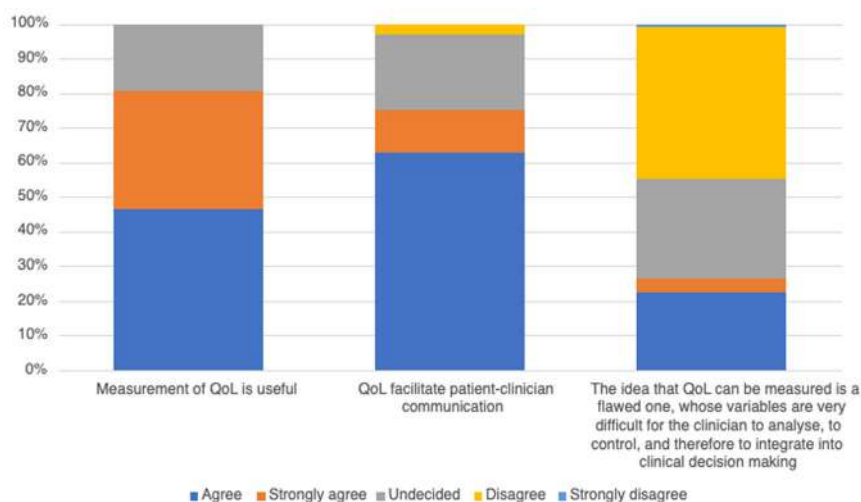


FIGURE 5 Strength of agreement of healthcare professionals (HCPs) on the benefit of quality of life (QoL) assessment (%)

practice, yet over half of participants never assessed QoL, and less than half rated their knowledge of QoL literature as poor or very poor. Although a different clinical area and patient group, these findings are consistent with those reported by Morris et al. who surveyed 260 oncologists and found that, although 80% believed that QoL should be measured prior to treatment, fewer than 50% of participants collected such information.<sup>22</sup> Evidently, there is disparity between perceived utility of QoL assessment and its implementation in clinical practice for HPN patients. The reasons for this are likely multifactorial, including the absence of clinical guidelines. For example, the BIFA produced a position statement on home parenteral support (HPS)<sup>23</sup> that simply states, 'The views and QoL of HPS patients, carers and families and the views of staff should be regularly audited' without providing any further information to guide such auditing. Additional reasons may include insufficient time, limited expertise of the QoL measure and possibly a lack of training and resources. These suggestions are supported by Skevington et al.,

who investigated the barriers to using QoL information in a cohort of general practitioners (GPs).<sup>24</sup> They reported that time was the greatest barrier, identified by 43% of respondents. Additional reasons for non-use were lack of understanding about how QoL data can be used and lack of evidence supporting its use. Of course, the patient population seen by these GPs includes a wide range of acute and chronic conditions that may not include patients on HPN. Unfortunately, there are no data specific to HCPs working within HPN. However, several interesting themes emerged within the additional comments section of the current survey that may help explain why some HCPs do not formally measure QoL in their patients. For example, one participant reported that 'QoL has so many different meanings to different people. Thus, measuring it and then generalising the findings is difficult'. Another participant explained: 'It may be difficult to measure and variable depending on the specific feelings of the patient on the day QoL is measured, however, it is important to assess QoL and integrate this into the care we provide'. A third comment

was, 'who decides quality of life? Performance status much more important and relevant'.

A major finding of this research is the inconsistency in QoL practice for patients treated with HPN. This includes the wide range of QoL instruments, both generic and disease specific, that are being utilised and the variation in frequency of QoL assessments, if at all. HPN-QoL<sup>11</sup> was the most familiar and frequently used tool among participants. This is possibly because it is the only tool referenced in the ESPEN 2016 and 2021 clinical guidelines on chronic IF.<sup>8,25</sup> The guidelines state that the HPN-QoL tool can be used for the one-off assessment of QoL as well as longitudinal changes in QoL and further state that the questionnaire is able to identify issues that impact QoL that could potentially be addressed by change aspects of the patient's clinical care. Multiple disease-specific measures are validated for use in patients on HPN (Table 2), and that makes comparison of the HPN population across different centres and countries very difficult. Of course, the absence of QoL tools in practice does not necessarily mean that QoL is not being assessed via other means. This suggestion was exemplified by two participants, who stated, 'Does it (QoL) need formal measurement on a scale? Or are these decisions part of holistic care between the patient and their clinician/s?' and 'None of the tools really work for me. Why does the medical profession persist on translating narrative into numbers? Much better to evaluate the QoL by talking to your patients as they can interpret the decisions required in the context of their QoL'.

Very few participants reported using the EQ-5D<sup>21</sup> and SF-36,<sup>12</sup> which are generic QoL and health utility

measures. They have been criticised for underrepresenting dimensions that may be specific to IF, such as the presence of a stoma or a catheter.<sup>27,28</sup> However, such measures should not be seen as alternatives to disease-specific questionnaires and, instead, complementary. Further inconsistencies in QoL practice include a large number of different reasons for assessing QoL and the variation in disseminating findings. Some HCPs do not disseminate findings, whereas others disseminate widely through conferences and journals. Further, several HCPs, across different professions and types of centres, did not know why QoL was being measured or why a particular tool was chosen.

Perhaps surprisingly, no respondents reported choosing a QoL measure based on patient preferences, and very few HCPs shared the results of QoL assessments with their patients. QoL instruments are designed to enable patients' perspectives of the impact of health and healthcare interventions on their lives to be assessed and considered in clinical decision-making and also in related research. Consequently, it was an unexpected finding that patients do not have an input on the choice of measure. One participant highlighted a similar point in the additional comments: 'But we use tools that we HCP have deemed suitable; in the age of PPI (patient and public involvement) I would like to see standardised rigorous tools that are PATIENT made. Why do we think we know what is a good reflector of QoL when we (usually) haven't actually lived the life?'. It is important to highlight that patients were involved in the development of the PNIQ,<sup>13</sup> which was developed through unstructured qualitative interviews with 30 HPN patients

TABLE 2 Summary of currently published disease-specific QoL measures

QoL measure	Year of publication	Country	Content	Method	Scoring
HPN-QoL <sup>3</sup>	2010	United Kingdom and New Zealand	48 items divided into three sections: 1. Global QoL 2. Effect of underlying illness 3. HPN on overall QoL  Summary score	Self-administered	Range 0–100 Higher scores = better QoL
PNIQ <sup>13</sup>	2018	England	20 statements with true (1) or not true (0)  Summary score	Self-administered	Range 0–20 Lower scores = better QoL
HPN-PROQ <sup>16</sup>	2017	United States	20 items with a five-point Likert scale and three items from the HPN-QoL tool  No summary score	Self-administered	No range Individual scores are utilised for discussion between the patient and HCP
New-QoL <sup>26</sup>	2016	Israel	35 items divided into general health and Likert-style questions to rate a participant's level of agreement and his or her intensity of feelings for a series of described states	Self-administered	Range 0–100 Higher scores = better QoL

Abbreviations: HCP, healthcare professional; HPN, home parenteral nutrition; IF, intestinal failure; PNIQ, parenteral nutrition impact questionnaire; PROQ, patient-reported outcomes questionnaire; QoL, quality of life.

and identified as being the first patient-centric HPN patient-reported outcome measure.<sup>13</sup> Similarly, 9 and 12 patients from the Scottish Home Parenteral Nutrition Managed Clinical Network were involved in the development of the HPN-QoL tool at stages 1 and 3, respectively.<sup>11</sup>

We found no significant differences in opinions about QoL assessment between the different professions involved in care of those treated with HPN nor was this related to length of experience. It seems that the opinions of HCPs are independent of profession and duration working with HPN patients. Similarly, there were no differences in opinions between those participants who do and do not measure QoL. Unsurprisingly, gastroenterologists and HCPs with more experience have better knowledge of the SF-36 QoL questionnaire.<sup>12</sup> The SF-36 is a generic health measure that was developed in the 1980s and has since been used in thousands of research studies, and it is likely that gastroenterologists have used this tool in other areas of their practice.

When participants were asked whether the complications associated with HPN treatment (IFALD, sarcopenia and sepsis) contribute to poor QoL, there was almost unanimous agreement that they did. With the exception of sepsis where there is literature to support the negative impact on QoL,<sup>29</sup> there is an absence of published literature detailing the contributions that liver disease and sarcopenia make to poor QoL. Therefore, these opinions must have been from clinical experience alone. Only one study specific to the HPN population has measured QoL in relation to nutritional status, liver function and blood tests. Blüthner et al. found that bioelectrical impedance of phase angle and serum citrulline and haemoglobin levels were independent risk factors for QoL in a cohort of 90 HPN patients.<sup>30</sup>

## STRENGTHS AND LIMITATIONS

What is considered as an acceptable response rate to a survey continues to be debated, with ranges from 60% to 75% being cited.<sup>31,32</sup> However, a recent online survey distributed to 904 physicians from various medical specialties reported mean responses of 35%.<sup>33</sup> Our finding of 41% response rate is similar, and the diverse range of HCPs who participated in the survey is a strength of our study. In addition, because the survey was completed by approximately 41% of the total cohort of professionals responsible for care of those undergoing HPN from different types of clinical units and from all four countries in the United Kingdom, it is likely that we have captured views of the relevant HCPs. Furthermore, questions were mandatory, meaning unit nonresponse, per question and any associated bias did not occur.

The study also has limitations. First, it is possible that the survey reached participants who were not part of the 23 centres that were contacted to assess sample

representation. Similarly, it is not known how many participants on the mailing list received the invitation to participate, and therefore, it is impossible to calculate an accurate response rate. It is possible that the knowledge and opinions of those who did not respond are different from those who did as these participants may have a personal interest in QoL. It is also possible that nonresponders feel less confident in their knowledge of QoL measures and may use them less than those with better knowledge. If so, the frequency of QoL assessment across the United Kingdom is likely to be less than that suggested by our findings. Second, the survey provides evidence of QoL practice within HPN care in the United Kingdom but did not explore the barriers and challenges that have led to such infrequent, or totally absent, QoL assessments for HPN patients. A third limitation is the heterogeneity within the types of centres surveyed. For example, specialised HPN and IF centres are very different in terms of knowledge and expertise, compared with 'other' types of centres that may treat a local patient on an ad hoc basis after a complication. However, only when asked whether QoL should influence the decision to commence palliative HPN were the differences in answers between centres significant.

## FUTURE RESEARCH

Because HCPs' perceptions of QoL may be at odds with those held by their patients, it remains important to ask patients to assess their own QoL using a reliable and valid measure. QoL should be measured in relation to the life-threatening and life-debilitating complications of HPN such as sepsis, liver disease and sarcopenia. Similarly, because the focus of this study was on the approach of HCPs to QoL and did not include carers who are often highly involved in the management of HPN, future research should explore this gap. In addition, future research could include qualitative interviews and focus groups which explore why there are inconsistencies in practice for QoL, how best to integrate QoL assessment into routine care and how the data may influence changes in the management of individual patients.

## CONCLUSION

The findings of this first study of knowledge, current practice and opinions of HCPs with regard to QoL and HPN highlight varying levels of knowledge of QoL literature and QoL tools among participants. There is also significant variability in QoL practice for patients treated with HPN. This is clear in terms of the relative infrequency in QoL assessments, heterogeneity in methodology and inconsistencies in how the results are utilised and disseminated. Less variable, however, were



the opinions of the HCPs, with almost unanimous agreement that the complications associated with HPN contribute to poorer QoL. Finally, despite the perceived usefulness and importance of QoL assessment, very few HCPs embed it into clinical practice, and even fewer share the findings with their patients. Evidently, there is a need for specific, evidence-based, clinical practice guidelines detailing how to define and measure QoL in this patient population.

### AUTHOR CONTRIBUTIONS

Colette Kirk designed the study with assistance from John C. Mathers, Nicholas P. Thompson, Mark S. Pearce and David E. Jones. John C. Mathers, Nicholas P. Thompson, Mark S. Pearce and David E. Jones supervised the project. Lisa Gemmell provided key participant contacts and assisted with survey dissemination. Colette Kirk conducted recruitment and data collection. Colette Kirk performed data analysis with assistance from Mark S. Pearce. Colette Kirk drafted the manuscript; all authors revised and approved the final version for submission.

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### CONFLICT OF INTEREST

The authors declare no conflict of interests.

### TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported, that no important aspects of the study have been omitted, and that any discrepancies from the study as planned have been explained.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Nutritional follow-up in children after discharge: Organisation in a tertiary care centre

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## Abstract

**Background:** Aiming to improve the standard of care for patients with a nutritional intervention, we evaluated how nutritional follow-up (FU) is organised at discharge and after 6 months.

**Methods:** From 16 November 2020 until 20 December 2020, we retrospectively included patients admitted for > 1 day to the general ward of a tertiary hospital. Medical charts were reviewed for demographics, anthropometric measurements and nutritional interventions (e.g., tube, parenteral nutrition). Involved healthcare provider (HCP), dietitian and speech and language therapist (SLT) were scored. Nutritional care FU was categorised as in a primary, secondary or tertiary care setting.

**Results:** We included 206 (52.4% male) patients, with a median length of stay of 4 (3–8) days. Prehospitalisation 58 (28.2%) patients had a nutritional intervention compared to 74 (35.9%) patients at discharge. In total, 80 (38.8%) patients received nutritional care FU by a total of 114 HCP, and approximately half (53.5%) were dietitians. FU was mostly conducted by a dietitian in the tertiary care (78.7%) and by an SLT in the primary care (54.5%). For 15 (20.3%) patients, the discharge letter included complete reports of nutritional interventions. At 6 months FU, 26.6% of the children still had a nutritional intervention. Mean weight standard deviation score increased significantly between discharge from the hospital and 6 months FU.

**Conclusions:** A considerable amount of paediatric patients received a nutritional intervention pre- and post-hospitalisation. Nutritional care is organised around a multitude of different HCP; however, not all cases are multidisciplinary. Nutritional care was scarcely reported correctly in the discharge letter.

## KEYWORDS

children, discharge letter, nutritional intervention, organisation, tubefeeding, weight

## Key points

- The present study evaluated how nutritional follow-up (FU) was organised at discharge and after 6 months.
- More children received a nutritional intervention post-hospitalisation than pre-hospitalisation.
- Nutritional FU was conducted by multiple healthcare providers (HCP) of which more than half were dietitians.
- The nutritional plan was poorly reported in the discharge letter with only one fifth containing complete reports.

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## INTRODUCTION

An imbalance between nutrient requirements and intake in children, which results in deficits in macronutrients and micronutrients, can be defined as paediatric malnutrition. Malnutrition can lead to growth and developmental impairment.<sup>1,2</sup> At admission, paediatric patients are often malnourished, ranging from 7.0% to 39.7%, or at risk of becoming malnourished.<sup>3–7</sup> Malnutrition at admission increases the length of stay, and thus the hospitalisation costs, and also decreases quality of life.<sup>5–7</sup> To identify children at risk for malnutrition upon admission screening tools such as the Screening Tool for Risk on Nutritional Status and Growth (STRONGkids) have been designed. It has been reported that a STRONGkids high risk classification is associated with a longer hospital stay and lower weight for height standard deviation score (SDS).<sup>8</sup>

To prevent and treat malnutrition and to prevent the adverse consequences of malnourishment a variety of nutritional interventions can be given, such as energy- and protein-enriched and disease-specific formulas. This is parallel to disease-specific treatment. In addition to disease-specific follow-up (FU), adequate FU of nutritional status can offer opportunities to optimise growth, nutritional status and recovery after discharge. A previous study of hospitalised critically ill children reported complete recovery of nutritional status 6 months after discharge in almost all subjects.<sup>9</sup> However, that study did not outline the means of nutritional FU and whether nutritional interventions were continued after discharge.

Aiming to further improve the standard nutritional care and FU for patients with a nutritional intervention or in need for nutritional FU, we evaluated how nutritional FU is organised in a tertiary care hospital. We were especially interested in children discharged with a nutritional intervention and the responsible healthcare provider (HCP) involved in nutritional care. Second, we evaluated the nutritional FU 6 months after discharge.

## METHODS

### Study design

We conducted a retrospective cohort study at the Erasmus Medical Centre Sophia Children's Hospital Rotterdam which is a tertiary care centre. We collected data from the electronic patient system of children who were discharged from the general ward between 16 November 2020 and 20 December 2020 and up to 6 months FU. The International Review Board reviewed our study and approved of our study protocol (MEC-2020-0949). The need for patient consent was waived.

### Inclusion and exclusion criteria

Inclusion criteria were (1) patients aged 0–18 years; (2) admitted to the general ward during the study period; and (3) length of hospital stay (LOS) longer than 24 h. In case of readmission, data were only included for the first admission episode. Exclusion criteria for evaluation were (1) premature neonates (birth at < 37 weeks of gestational age) who had not reached corrected term age and (2) death during admission. Patients were excluded for the 6-month FU period if they died within 6 months after discharge and/or did not receive clinical or outpatient FU in our hospital.

### Data collection

Medical charts were reviewed regarding gender, age, LOS, diagnostic category and paediatric intensive care unit (PICU) admission before admission to the general ward. Age groups were defined as neonates (until 28 days of age), infants (28 days until 1 year of age) and children (older than 1 year). The STRONGkids score was noted if measured within 24 h after admission with a score of 0 indicating low risk, 1–3 indicating medium risk, and 4 and 5 indicating high risk for malnutrition.<sup>8</sup> Anthropometric measurements, including weight and height, were obtained from medical charts before admission (up to 1 year before admission), upon admission, discharge and up to 6 months after discharge. Measurements were converted to SDS using the Dutch TNO growth charts for patients older than 7 days and the Fenton growth chart was used for neonates younger than 7 days.<sup>10,11</sup> The Dutch TNO growth charts were corrected for prematurity until patients reached 2 years of age. Corrected growth charts were also used for patients with Down's syndrome. Acute malnutrition was defined as  $\leq 2$  SDS weight for age in patients < 1 years old and  $\leq 2$  SDS weight for height in patients  $\geq 1$  years old. Chronic malnutrition was defined as height SDS  $\leq 2$  for all ages.

Readmissions after discharge (admission longer than 24 h) and duration of nutritional FU in Sophia Children's Hospital were recorded.

To investigate the organisation of nutritional FU, data were collected on involved HCP; dietitian and/or speech language therapist (SLT) and/or paediatrician. FU by an SLT was only scored if it concerned nutritional problems. The referral of nutritional care was defined as a primary, secondary or tertiary care setting. These data were collected from medical charts and discharge letters from the involved medical doctor during hospital stay. FU by a paediatrician was scored both on disease specific FU and FU related to nutritional care, growth and/or malnutrition. When FU was not performed in our hospital, discharge letters were screened concerning recommendations about FU for nutritional care and growth-related problems. Data were collected both on nutritional intervention upon admission and discharge

specified in administration route, that is oral, enteral, parenteral and type of nutrition, that is energy- and protein-enriched diet and disease-specific diet, both with and without supplements and standard supplements. Supplements were defined as modules, formulas, sip feeding and tube feeding. Additionally, discharge letters were screened on reporting nutritional care at discharge (i.e., intervention, type of nutrition, special diets).

Data were collected up to 6 months after discharge on anthropometric measurements, nutritional interventions, involved HCP and care setting regarding nutritional care in the Sophia Children's Hospital (patients were not included if FU was exclusively conducted in another hospital).

## Outcome measures

The primary outcome measure was the organisation of nutritional FU after discharge up to 6 months FU. The FU was outlined as number and type of involved HCP and care setting. Moreover, nutritional interventions, absolute numbers and type and route, were analysed during the study period.

Secondary outcome measures were nutritional intervention at discharge, dietitian or SLT consulted during hospitalisation and dietitian, SLT or paediatrician involved during FU in six predefined subgroups. These subgroups are (1) patients with a reported STRONGkids score within 24 h after admission; (2) LOS subdivided in hospitalisation shorter than 4 days and longer than 4 days; (3) age groups; (4) PICU admission during admission; (5) diagnostic categories; and (6) malnutrition at admission. Finally, weight change before admission, during admission and 6 months after discharge were recorded.

## Statistical analysis

Statistical analyses was performed using SPSS, version 25 (IBM Corp.). Categorical variables were summarised as frequencies and percentages. Continuous variables were reported as medians and interquartile ranges or means and SD. Descriptive statistics were mostly used. Normality of data was tested using the Kolmogorov–Smirnov test. Continuous variables were compared using a paired samples *t* test. Categorical variables were compared using a chi-squared test or Fisher's exact test.  $p < 0.05$  were considered statistically significant. If multiple comparisons were made, a Bonferroni correction was used.

## RESULTS

### Baseline characteristics

From 16 November 2020 until 20 December 2020, 602 patients admitted to the paediatric general ward were

screened for eligibility. LOS was shorter than 24 h in 379 patients, 12 patients were readmitted, four patients had not reached corrected at term age and one patient died; therefore, they were excluded. In total, 206 patients were included in the analysis.

Table 1 shows the baseline characteristics of the included patients. On admission acute malnutrition was present in 5.9% of the children  $< 1$  year and 7.3%  $> 1$  year. Chronic malnutrition was present in 13.6% of the patients (8.7%  $< 1$  year and 91.3%  $> 1$  year). In 161 patients, with a measured weight and height, acute and chronic malnutrition was present in 34 patients (21.1%). In 105 patients, STRONGkids score was measured and showed a low risk in 60 patients (57%), medium risk in 43 patients (41%) and high risk in two patients (2%).

For the 6-month FU period, 18 patients were excluded, 13 patients received no FU and five patients died. One hundred and 88 patients (91.3%) received FU in our hospital after discharge. FU periods differed between patients. For the FU period, data were available until 1 month after discharge in 18 patients (9.6%), up to 2 months in 10 patients (5.3%), up to 3 months in 21 patients (11.2%), up to 4 months (6.4%) in 12 patients, up to 5 months in 16 patients (8.5%) and up to 6 months in 111 patients (59.0%). After 6 months, 164 patients (79.6%) were still in FU, either disease-specific or nutritional. During the 6-month FU period, 34 patients (18.1%) were readmitted once, 14 patients (7.4%) twice, four patients (2.1%) three times and three patients (1.6%) four times.

### Nutritional care prehospitalisation and during hospitalisation

Prehospitalisation 58 patients (28.2%) had a nutritional intervention: 39 medical patients (67.2%) and 19 surgical patients (32.8%) (Figure 1). In 50 of the 58 patients (86.2%), a dietitian was already involved and, in 12 patients (20.7%), a SLT was involved. During hospitalisation, another 20 patients received a nutritional intervention. In four patients (6.9%), the nutritional intervention at admission was completed before or at discharge. During admission, a dietitian and/or SLT was involved in 70 patients (34.0%) of whom 35 patients already had involvement before admission and 35 patients were new patients.

### FU after discharge

At discharge, 74 patients (35.9%) had a nutritional intervention (Figure 1); 38 patients of these patients (51.4%) received partial of complete enteral nutrition tube feeding, of whom 17 patients (44.7%) had a gastrostomy tube. Five patients (6.8%) received (partial) home parenteral nutrition. The administration route for the intervention was oral in 31 patients (41.9%).

TABLE 1 Baseline characteristics

Characteristics	Number of patients	Results
Male, <i>n</i> (%)	206	108 (52.4)
Age at inclusion, median years (IQR)	206	4.5 (1.0–12.2)
Age groups	206	
Neonate < 28 days, <i>n</i> (%)		14 (6.8)
Infants ≥ 28 days and ≤ 1 year, <i>n</i> (%)		38 (18.4)
Children > 1 year, <i>n</i> (%) (%)		154 (74.8)
LOS, median days (IQR)	206	4.0 (3–8)
Malnutrition at admission <sup>b</sup>		
Weight SDS (< 1 year), <i>n</i> (%)	51	3 (5.9)
Weight to height SDS (> 1 year), <i>n</i> (%)	124	9 (7.3)
Height SDS, <i>n</i> (%)	169	23 (13.6)
STRONGkids, <i>n</i> (%)	105	
Low risk		60 (57.1)
Medium risk		43 (41)
High risk		2 (1.9)
Diagnostic group, <i>n</i> (%)	206	
Surgical		117 (56.8)
Orthopaedic		25 (12.1)
Abdominal		22 (10.7)
Cardiac		20 (9.7)
Neurologic		20 (9.7)
Urologic		16 (7.8)
Trauma		7 (3.4)
ENT		4 (1.9)
Other		3 (1.5)
Medical		89 (43.2)
Neurologic		20 (9.7)
Gastrointestinal/urologic		19 (9.2)
Other		16 (7.8)
Respiratory		9 (4.4)
Inflammatory/auto-immune		8 (3.9)
Oncologic		8 (3.9)
Infection (non-cardiac/respiratory/gastro-intestinal)		5 (2.4)
Cardiac		4 (1.9)
Admitted to PICU during hospitalisation, <i>n</i> (%)	206	

(Continues)

TABLE 1 (Continued)

Characteristics	Number of patients	Results
No admission		143 (69.4)
Elective admission		35 (17.0)
Non-elective admission		28 (13.6)

Abbreviations: ENT, ear, nose and throat; HC, head circumference; LOS, length of stay; PICU, paediatric intensive care unit; SDS, standard deviation score; STRONGkids, Screening Tool for Risk on Nutritional Status and Growth.

<sup>a</sup>≤ 7 days Fenton growth chart, > 7 days TNO growth chart.

<sup>b</sup>Malnutrition was defined as SDS ≤ -2.

In 38 patients (51.4%), the nutritional intervention consisted of a disease-specific diet of whom 30 patients used disease-specific supplements (modules, formulas, sip feeding and tube feeding). In 16 patients (21.6%) energy- and protein-enriched supplements were prescribed. In the other 20 patients (27%), either standard supplements or energy- and protein-enriched diet advice was administered.

From the 74 patients with a nutritional intervention at discharge, four patients did not receive nutritional FU because the clinician judged this was not needed. Another 10 patients who did not receive a nutritional intervention at discharge received FU for nutritional care anyway. The reason for FU in these patients was growth in two patients, monitoring intake in one patient, training oral feeding in two patients, growth and training oral feeding in two patients, obesity in one patient, and probable onset of disease-related feeding problems in two patients. Overall, a total of 80 patients received nutritional FU.

Two hundred and three (98.5%) patients received disease-specific FU by a paediatrician. In the 80 patients receiving nutritional FU, 114 HCPs were involved. A dietitian was involved in 61 (76.3%) patients, a SLT in 22 (27.5%) patients and a paediatrician in 31 (38.8%) patients (Table 2). Furthermore, multiple combinations of HCP were possible, with the most frequent nutritional FU consisting of a dietitian and paediatrician (*n* = 9; 11.3%) and a dietitian, SLT and paediatrician (*n* = 7; 8.8%). In five patients, a paediatrician and SLT (6.3%) conducted the FU and, in six patients, a dietitian and SLT (7.5%).

FU by a dietitian was predominantly received in the tertiary care setting (78.7%), either in the Sophia Children's Hospital or in a tertiary care hospital elsewhere (Table 2). However, SLT mostly organised their FU in the primary care setting (54.5%) and paediatricians divided their dietary care equally between secondary and tertiary care setting (45.2% vs. 51.6%).

In 15 patients (20.3%), the discharge letter mentioned the correct nutritional intervention including administration route, specific diet and/or formula and quantities (Table 3). In 16 patients (21.6%) with an intervention at discharge, there was no mention of a nutritional



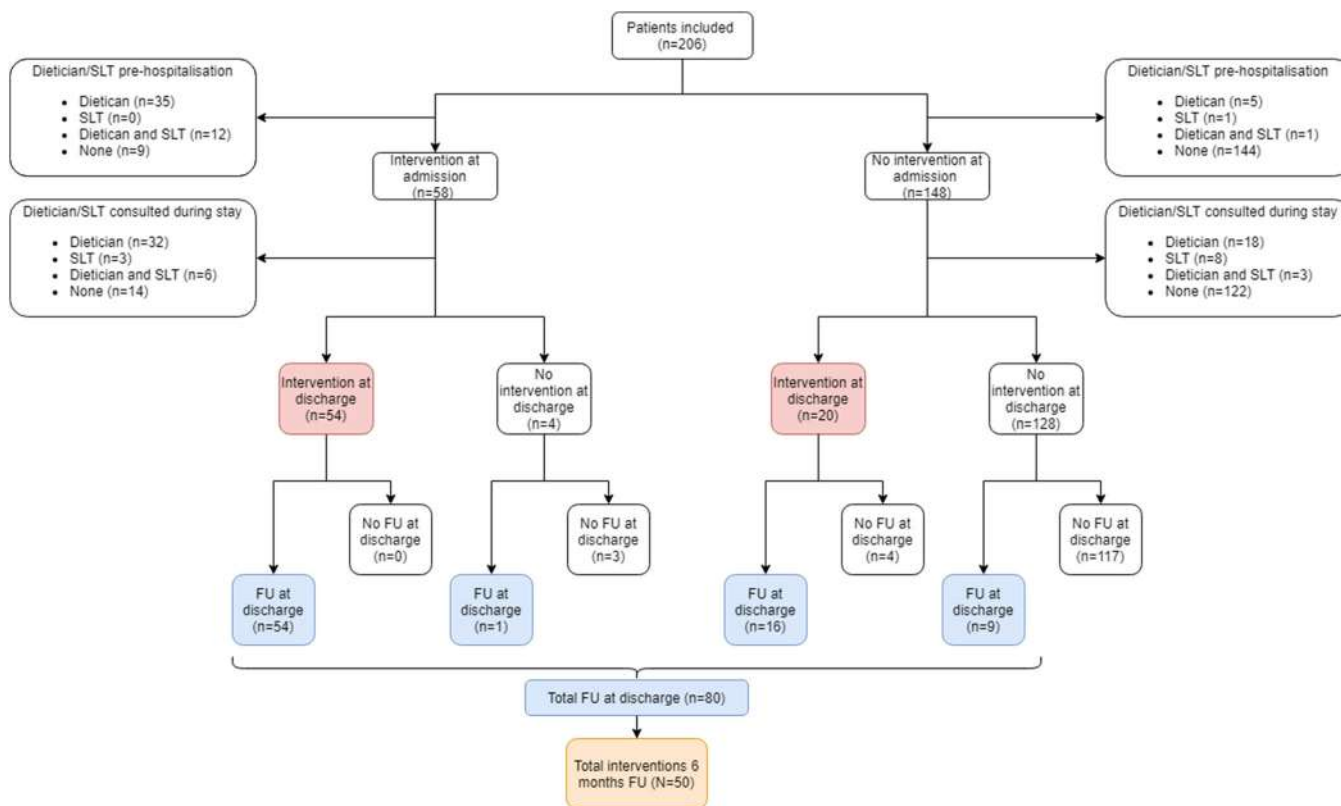


FIGURE 1 Flow chart of nutritional care at admission until discharge Intervention is classified as a nutritional intervention. In total, 74 children had an dietary intervention at discharge and 80 children received nutritional follow-up after discharge. FU, follow-up; SLT, speech and language therapist.

	Primary care	Secondary care	Tertiary care Sophia	Tertiary care
Dietitian (n = 61), n (%)	2 (3.3)	11 (18.0)	41 (67.2)	7 (11.5)
SLT (n = 22), n (%)	12 (54.6)	5 (22.7)	5 (22.7)	0
Paediatrician (n = 31), n (%)	1 <sup>a</sup> (3.2)	14 (45.2)	11 (35.5)	5 (16.1)

TABLE 2 Care setting follow-up per healthcare provider

Notes: In 80 patients nutritional follow-up was conducted with a total of 113 healthcare providers involved. The table shows in which care setting follow-up was conducted per healthcare provider.

Abbreviation: SLT, speech and language therapist.

<sup>a</sup>General practitioner.

intervention in the discharge letter. In 43 patients (58.1%), no completely correct prescription of the nutritional plan was found.

### FU after discharge

Six months after discharge, 50 of 188 patients (26.6%) still received a nutritional intervention. In seven patients with a nutritional intervention at admission, there were no FU data, in 22 patients the intervention was discontinued and, in five patients, a nutritional intervention was started after discharge. In patients where the intervention was stopped, 11 patients (50.0%) received

enteral nutrition and 11 patients (50.0%) received oral nutrition. Twenty-one patients (42.0%) received partial or complete enteral nutrition at 6 months FU, 17 patients had a gastrostomy tube and four patients a nasogastric tube. In the 21 patients with a nasogastric tube at discharge, four patients had no FU, four patients still had a nasogastric tube at 6 months FU and, in 13 patients, the nasogastric tube was discontinued. In the group where the nasogastric tube was discontinued, one patient received a gastrostomy tube and one patient transitioned to parenteral nutrition. One of the five patients with (partial) home parenteral nutrition at discharge was weaned off parenteral nutrition 6 months after discharge.

TABLE 3 Nutritional information in discharge letter

	<i>n</i> = 74
Correct mention, <i>n</i> (%)	15 (20.3)
Partly correct mention, <i>n</i> (%)	
Administration route missing	4 (5.4)
Specific diet/formula missing	3 (4.1)
Quantities missing	4 (5.4)
Quantities and specific diet/formula missing, correct route	9 (12.1)
Quantities and route missing, correct formula/diet	1 (1.4)
Mention of intervention, no specification	22 (29.7)
No mention of a nutritional intervention, <i>n</i> (%)	16 (21.6)

Notes: Nutritional information reported in the discharge letter. Correct mention included administration route (i.e. oral, enteral, parenteral), specific mention of diet/formula (i.e. ketogenic diet, fibre enriched) and quantities.

## Nutritional care in predefined subgroups

Table 4 shows subgroups of our population in relation to nutritional care. More nutritional interventions at discharge, increased involvement of dietitians and SLT, and higher nutritional FU rates were found in children with a higher STRONGkids score, in malnourished children, in children with a longer LOS and in children within the medical diagnostic group. The results were statistically significant, except for increased involvement of a dietitian and/or SLT in medium- and high-risk STRONGkids score children.

## Weight course during admission and after discharge

In 111 children (53.9%), weight was measured at admission and at discharge. The mean SDS for weight

TABLE 4 Nutritional care in predefined subgroups

	Number of patients	Intervention at discharge	HCP during hospitalisation <sup>c</sup>	FU HCP
STRONGkids, <i>n</i> (%)	105	<i>p</i> < 0.001		<i>p</i> = 0.002
Low risk ( <i>n</i> = 60)		11 (18.3)*	14 (23.3)	14 (23.3)*
Medium and high risk ( <i>n</i> = 45)		24 (53.3)	18 (40.0)	24 (53.3)
PICU admission, <i>n</i> (%)	206			
Yes ( <i>n</i> = 63)		21 (33.3)	23 (36.5)	21 (33.3)
No ( <i>n</i> = 143)		53 (37.1)	47 (32.9)	59 (41.3)
Acute malnutrition at admission, <i>n</i> (%) <sup>a</sup>	175	<i>p</i> = 0.03	<i>p</i> = 0.03	<i>p</i> = 0.01
Yes ( <i>n</i> = 12)		8 (66.7)	8 (66.7)	9 (75.0)
No ( <i>n</i> = 163)		55 (33.7)	53 (32.5)	61 (37.4)
LOS, <i>n</i> (%)	206	<i>p</i> < 0.001	<i>p</i> < 0.001	<i>p</i> = 0.01
≤ 4 days ( <i>n</i> = 105)		25 (23.8)*	19 (18.1)*	32 (30.5)
> 4 days ( <i>n</i> = 101)		49 (48.5)	51 (50.5)	48 (47.5)
Age groups, <i>n</i> (%) <sup>b</sup>	206			
Neonates ( <i>n</i> = 14)		5 (35.7)	9 (64.3)	6 (42.9)
Infants ( <i>n</i> = 38)		11 (28.9)	9 (23.7)	14 (36.8)
Older children ( <i>n</i> = 154)		58 (37.7)	52 (33.8)	60 (39.0)
Diagnostic category, <i>n</i> (%)	206	<i>p</i> < 0.001	<i>p</i> < 0.001	<i>p</i> < 0.001
Surgical ( <i>n</i> = 117)		23 (19.7)*	26 (22.2)*	27 (23.1)*
Medical ( <i>n</i> = 89)		51 (57.3)	44 (49.4)	53 (59.6)

Abbreviations: FU, follow-up; HCP, healthcare professional; LOS, length of stay; PICU, paediatric intensive care unit; SLT, speech and language therapist.

<sup>a</sup>Malnutrition was defined as SDS ≤ -2 on weight standard deviation score, height standard deviation score or weight for height standard deviation score.

<sup>b</sup>Neonates < 28 days; infants ≥ 28 days and ≤ 1 year; children > 1 year.

<sup>c</sup>Paediatrician not included, automatically involved during hospitalisation.

\*Significant using the Bonferroni correction calculated, *p* = 0.003.

at admission was  $0.05$  ( $SD \pm 1.6$ ) and, at discharge, it was  $-0.2$  ( $SD \pm 1.5$ ). For children with an intervention at admission, the mean SDS for weight at admission was  $-0.9$  ( $SD \pm 1.8$ ) and, at discharge, was  $-0.6$  ( $SD \pm 1.6$ ). Thirteen children (11.7%) had a weight SDS  $\leq 2$  at discharge. Fifty-four children (48.6%) lost weight during their admission with a median percentage of weight loss of  $-2.7\%$  [interquartile range (IQR) =  $-5.5$  to  $-1.4$ ]. In 39 (72.2%) patients, weight loss was between 0% and 5% and, in 15 (27.8%) patients, weight loss was  $\geq 5\%$ . When dividing the 111 patients in a group in which a dietitian was involved or not during hospital stay, weight loss was present in 54.2% and 44.4%, respectively, of patients.

In Figure 2, the weight SDS during the study period is depicted in children with and without an intervention at admission.

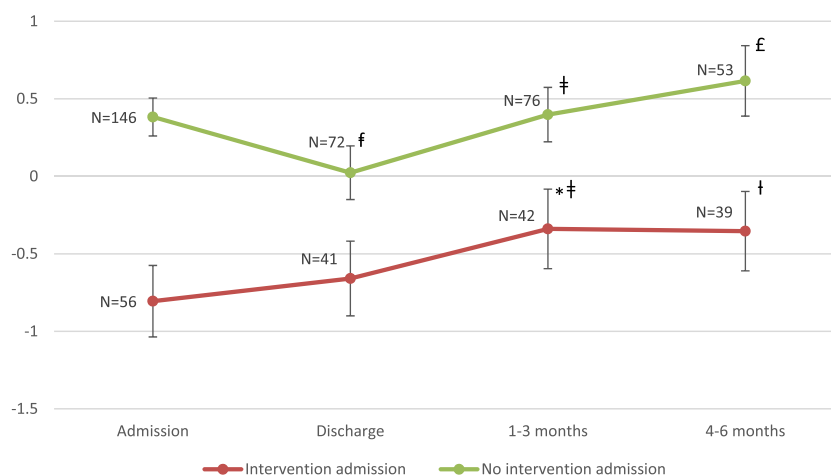
## DISCUSSION

In the present study, we aimed to investigate the organisation of nutritional FU in 206 children who were admitted to the general ward in a tertiary care hospital for more than 24 h. At discharge, a total of 74 patients (35.9%) and 80 patients (38.8%), respectively, received a nutritional intervention and nutritional FU. In these 80 patients, 114 HCP's were involved, with a multitude of combinations possible and in different care settings. In only 20.3% of the patients with a nutritional intervention at discharge, the correct intervention was mentioned in the discharge letter. During FU, the number of patients with a nutritional intervention had decreased (26.6%). Mean weight SDS increased significantly between discharge and 6 months after discharge, and also in children with a nutritional intervention.

Upon admission, 58 patients (28.2%) received a nutritional intervention that is much higher than previously described (11.8%).<sup>7</sup> During hospitalisation, a nutritional intervention was started in 20 patients which contained oral, enteral or parenteral feeding strategies. We found that longer LOS, higher STRONGkids score, medical diagnostic group and malnutrition upon admission were associated with more nutritional interventions, involvement of dietitian/SLT during stay and nutritional FU. One study also showed a significant difference between increasing STRONGkids risk groups and the percentage of interventions per risk group ( $p < 0.05$ ).<sup>12</sup>

In the present study, 48.6% of the children lost weight during admission (median weight loss 2.7%; IQR = 1.4–5.5), which is in accordance with previous studies.<sup>5,7</sup> However, we did not find a difference in weight loss between patients consulted or not consulted by a dietitian (54.2% vs. 44.4%). This is in contrast to a Canadian study in which it was shown that the percentage of patients who lost weight was significantly higher in patients not visited by a dietitian.<sup>5</sup> We argue that the effect of a dietitian involved during hospitalisation on weight gain can hardly be concluded from a population with a median LOS of 4 days but has to be judged in patients with a longer hospital stay and in FU after discharge.

The percentage of children receiving a nutritional intervention at discharge (35.9%) is also higher compared to previous studies (ranging from 12.1% to 17.3%).<sup>13,14</sup> This difference might be explained by the present study being performed in a tertiary academic hospital. Furthermore, our higher rates of nutritional intervention could be a result of the previous studies using less broader definitions of nutritional interventions. Six months after discharge, the nutritional intervention rate



**FIGURE 2** Mean standard deviation score for weight from admission until 6 months after discharge. Standard deviation score for weight from admission, at discharge, after 1–3 months after discharge and 4–6 months after discharge. All values are expressed as the mean  $\pm$  SEM. <sup>f</sup>Value is statistically significant compared to admission,  $p < 0.05$  ( $n = 71$ ). <sup>\*</sup>Value is statistically significant compared to admission,  $p < 0.05$  ( $n = 41$ ). <sup>†</sup>Value is statistically significant when compared to admission,  $p < 0.05$  ( $n = 37$ ). <sup>‡</sup>Value is statistically significant compared to discharge,  $p < 0.05$  ( $n = 41$ ;  $n = 31$ ). <sup>‡</sup>Value is statistically significant compared to discharge,  $p < 0.05$  ( $n = 23$ ).

decreased to 26.6% and we noted a significant improvement overall of the weight SDS, implying the effect of nutritional intervention. Importantly, in 13 children, nasogastric tube feeding could be stopped and, in one child, parenteral nutrition could be stopped.

The care setting where FU was conducted differed among HCPs. For dietitians, it was mostly concentrated in the tertiary care setting; for SLT, it was mostly concentrated in the primary care setting; and, for paediatricians, it was equally concentrated in the secondary and tertiary care setting. Interestingly, in only one-third of the children, nutritional FU was conducted by two or three HCPs, which might be necessary in all children with a nutritional intervention. At the very least, it is recommended that the standard care for tube-fed children is performed in a multidisciplinary team.<sup>13</sup> Furthermore, a comment by the ESPGHAN Committee on Nutrition suggests the implementation of a nutrition support team in paediatric units.<sup>14</sup> The team should be multidisciplinary consisting of paediatrician specialised in nutrition, a dietitian, a nurse and, if possible, a pharmacist. The goal of this team would be screening patients for nutritional risk, identifying children in need of nutritional support, providing nutritional management, and education and training of hospital staff. Barriers for adequate nutritional care are identified as lack of personnel or resources to carry out screening and measurements, lack of awareness (importance nutrition, limited education/training) and lack of a protocol managing undernutrition.<sup>15</sup> These barriers should be tackled by introducing more education during the nursing and medical curriculum about nutrition and create awareness through clinical lessons/presentations.

An astonishing result of our study was that, in only 20.3% of the patients with a nutritional intervention at discharge, the correct intervention was mentioned in the discharge letter, whereas, in 21.6% of the patients, there was no mention at all of an intervention in the discharge letter. This result calls for action and improvement. A Canadian study conducted in an adult diabetic population evaluated the content and quality of the discharge letter (to a primary physician) with and without using a discharge letter template.<sup>16</sup> The letters created using a template more frequently included risk factors, disease-specific management options and re-referral criteria. The use of similar templates could be an outcome for our population, first of all to increase the complete mention of the nutritional intervention at discharge and to set patient-specific nutritional goals. In addition, up-to-date information from a SLT or dietitian should be included.

Although a considerable percentage of our population lost weight after admission, weight SDS resorted after discharge. There was a significant difference in weight SDS between admission and directly at discharge compared to 1–3 months and 4–6 months after discharge, as well as in patients who already had a nutritional intervention at admission. This is in agreement with a

previous study from our centre in which patients who were admitted to the intensive care had a restored weight SD score 6 months after discharge.<sup>9</sup> This emphasises the need for careful evaluation of the effect of nutritional therapy on growth after discharge and to set goals for nutritional treatment in relation with growth parameters.

Although the present study was performed in a relatively large sample and it was the first study to outline nutritional care in a tertiary care hospital in such an extensive manner, study limitations should also be addressed.

The retrospective study design makes our study prone to bias. To minimise the risk of bias, we screened the discharge letter, electronic patients files and old discharge/outpatient clinic letters for potential information. We missed anthropometric data on discharge in 53.9% of the patients, which is an example of missing data because of the retrospective character of the study. This could potentially lead to distorted data.

Furthermore, essential information about FU (before and after the study period) in another hospital could be missed because we had no access to these records.

In conclusion, a substantial number of patients, both prehospitalisation and with increasing numbers posthospitalisation, received a nutritional intervention, which indicates widespread usage in a tertiary care hospital. The nutritional FU consisted of a multitude of different types and combinations of HCPs who conducted FU in different care settings. In the discharge letter from the hospital, the nutritional plan and latest advice from a dietitian and/or SLT was poorly reported.

Future nutritional intervention studies at discharge are needed to demonstrate which nutritional support therapy enables the best improvement in clinical and health-related outcome, quality of life, and well-being of the child and parents/caregivers.

## AUTHOR CONTRIBUTIONS

*Development of project idea:* Marissa Kooij, Emma Koster, Renate Eveleens and Koen Joosten. *Data collection:* Marissa Kooij. *Data analysis:* Marissa Kooij and Renate Eveleens. *Review and interpretation of data:* Marissa Kooij, Emma Koster and Koen Joosten. *Drafting of manuscript:* Marissa Kooij and Emma Koster. *Project supervision:* Koen Joosten.

## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained. The International Review Board

reviewed our study and approved of our study protocol (MEC-2020-0949).

## PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1111/jhn.13083>.

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# Attitudes, work roles and barriers to nutrition care – interviews with Australian and UK-based medical doctors

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## Abstract

**Background:** Poor diet is implicated in multiple chronic diseases. Although doctors may be well placed to facilitate nutrition care, nutrition remains a low priority in medical education internationally. Consensus is required on nutrition competencies as a benchmark for education with a regulatory framework to ensure implementation. The aim of this qualitative study was to explore work roles, attitudes, barriers and enablers in the delivery of nutrition care among a cohort of Australian and UK doctors.

**Method:** Semi-structured interviews were conducted with primary care doctors/general practitioners ( $n = 14$ ) and medical specialists ( $n = 8$ ) based in Australia and the United Kingdom to explore work roles, attitudes, barriers and enablers in the delivery of nutrition care.

**Results:** Framework analysis identified five key themes: (1) knowledge and skills in nutrition to support medical nutrition care, (2) the delivery of nutrition education, (3) multidisciplinary and interdisciplinary care, (4) systemic barriers and facilitators to care and (5) the need for a paradigm shift. Participants acknowledged nutrition as an important component of medical care but recognised they are currently ill-equipped to support such care, identifying limitations to the systems supporting integrated care. Participants identified that nutrition sits within both a health promotion and medical/treatment model, but they currently work only within the latter.

**Conclusion:** Participants highlighted a lack of knowledge and training regarding nutrition, without which change is not possible. Efforts to improve the nutrition capacity of the medical workforce must be matched by increased investments in primary prevention, including nutrition – a paradigm shift from the medical model.

## KEYWORDS

competency framework development, medical education, nutrition, nutrition care, nutrition education

## Key points

- This qualitative study explores work roles, attitudes, barriers and enablers in the delivery of nutrition care among a cohort of Australian and UK doctors.

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- Doctors acknowledge nutrition as an important component of nutrition care but are ill-equipped to support such care, identifying limitations to the systems that might support integrated care.
- Efforts to build the nutrition capacity of the medical workforce must be matched by increased investments in primary prevention, including nutrition – a paradigm shift away from a traditional medical (treatment) model.

## INTRODUCTION

The role of nutrition in health and well-being is recognised internationally. Good nutrition promotes maternal, infant and child health; supports normal growth, development and ageing; and reduces the risk of disease.<sup>1</sup> Poor diet is now the leading risk factor for death, responsible for 11 million deaths annually.<sup>2</sup> The integration of nutrition interventions across the health-care continuum is considered a critical action to end malnutrition in all its forms, though primary prevention remains the cornerstone of public health efforts.<sup>3,4</sup> The delivery of nutrition care through health systems is a key strategy to support population dietary improvements. Doctors in primary care, in particular, have the potential to elicit improvements in nutrition behaviour and are powerful role models.<sup>5</sup> For example, general practitioners (GPs) frequently encounter presentations of non-communicable disease or malnutrition, for both of which nutrition is a significant risk factor. In Australia in 2015–2016, one in three conditions managed by GPs was chronic, and about half (51.6%) of the patients who visit a GP have two or more diagnosed chronic conditions.<sup>6,7</sup> In the United Kingdom, more than 3 million people are either malnourished or at risk of malnutrition at any given point, and 93% of these are living in the community.<sup>8</sup> GPs' regular contact with their patients also provides opportunities for referral to other nutrition services, such as dietitians, when further expertise is required.

Hospital-based doctors may also have a role to play in addressing the exigent double burden of malnutrition, as they are typically exposed to the secondary symptoms of noncommunicable diseases, for which nutrition is a leading modifiable risk factor.<sup>9</sup> In this setting, the rates of under-nutrition remain high, averaging 35% internationally, and more importantly, the prevalence is also high predischarge.<sup>10</sup> Thus, there is an opportunity to optimise nutrition care to improve health outcomes for patients and the community across the continuum of care. Despite these opportunities, there is evidence that the medical profession engages in nutrition care at less-than-desirable rates, and clinicians report insufficient nutrition knowledge, skills and confidence as barriers to nutrition care in practice.<sup>11–14</sup> For example, in a recent study, GPs in Ireland reported that they have insufficient knowledge to change or discontinue oral nutrition supplement prescriptions in practice.<sup>15</sup>

A key element of the health workforce is the education system supporting their development. Nutrition education in medical training is imperative to ensure graduates are supported to facilitate nutrition care as part of routine medical practice. However, although efforts to enhance medical nutrition education have persisted for decades, it remains inadequate, regardless of country, setting or year of medical education.<sup>13</sup> The use of a competency-based approach in enhancing medical nutrition education has been previously established and has been shown to improve the ability to integrate nutrition into patient care.<sup>16</sup> There is a well-recognised gap which exists between the nutrition competencies required for the delivery of nutrition care and current medical nutrition education. Recent developments in this space, such as the Association for Nutrition UK Undergraduate Curriculum for Nutrition for Medical Doctors, published in 2021, and the European Society for Clinical Nutrition and Metabolism position paper on nutrition education in medical schools, aim to identify minimum requirements for nutrition in undergraduate medical education.<sup>17,18</sup> However, there remains a need for consensus on a competency model as a benchmark for medical education across the continuum. An essential activity to define potential competency standards is the inclusion of the perspective of key stakeholders, in particular the medical profession. Interviews have been used to facilitate in-depth exploration of complex phenomena, such as behaviour, and to explore themes around professional competence.<sup>19–21</sup> Therefore, this study used interviews with the aim to explore work roles, attitudes, barriers and enablers in the delivery of nutrition care among a cohort of Australian and UK doctors in primary, secondary and tertiary care.

## METHODS

### Study design overview

Online, semi-structured interviews were conducted with primary care doctors/GPs of both pre- and postregistration and medical specialists based in Australia and the United Kingdom. The University of Wollongong Human Research Ethics Committee approved this study (protocol number: 2020/062). Participants were provided with an information sheet, and all participants provided

informed consent via a consent form or recorded verbal consent before participating in an interview.

## Participants

Purposive sampling was undertaken to ensure diversity in gender, location (i.e., rural, remote and metropolitan), professional experience and involvement in delivery of nutrition care. Participants were required to have postregistration as a medical practitioner and be working towards or qualified as a GP or other medical specialist, registered by the Australian Health Practitioner Regulation Agency (AHPRA), the General Medical Council (GMC) (UK) or another international regulator. A doctors from the United Kingdom have similar models of medical education and healthcare systems, they were added to the Australian sample to provide additional insights into the provision of nutrition care. Participants were identified through the networks of the research team and invited to participate in an online interview via email.

## Data collection

The questions were based on a preliminary review of the literature pertaining to medical nutrition education and published guidance for nutrition competencies for medicine.<sup>22,23</sup> Questions were open and closed in nature to provide flexibility in discussion and to identify areas of convergence. Interview questions were related to perception of work roles and barriers in the provision of nutrition care and the key skills, knowledge and attitudes (competencies) required to deliver such care (Table 1). Questions were piloted with one individual, and question order was modified to improve sequencing. Coding of data occurred simultaneously to data collection, and themes were continuously reviewed and refined until no new themes emerged.

## Data analysis

Interviews were audio-recorded using Zoom Video Communications Inc. videoconferencing software and transcribed verbatim using Otter AI. Transcripts were then imported into QSR International's NVivo 9 software for analysis. Data were de-identified and stored on a password-protected computer to ensure data protection.

The framework method was utilised for data analysis in this study.<sup>24</sup> The framework method is increasingly being used in multidisciplinary and applied health research, in particular where there is patient and public involvement. Initially, two members of the research team (B.L. and E.J.B., both dietitians) used open coding to independently code the same three transcripts.

These researchers then developed an initial working codebook of themes that included *a priori* themes of interest and new themes that resulted after both researchers read all transcripts in their entirety. Three research team members (B.L., K.J.M. [medical scientist] and E.J.B.) then coded the remaining transcripts in duplicate while meeting periodically to review and discuss any discrepancies in coding. Analysis involved the systematic comparison of coded segments across interviews to identify convergent, salient and/or unique themes. All authors met to discuss the analysis and interpretations and agree on key themes. An example of coding framework is provided in Supporting Information: Supplementary Materials.

## RESULTS

Twenty-two individual online interviews were conducted with primary care doctors/GPs ( $n = 14$ ) and hospital-based doctors ( $n = 8$ ) between December 2020 and July 2021. Interviews lasted between 9 and 51 min, with an average duration of ~23 min. There were an equal number of participants who identify as male or female with median age of 40–44 years, and all participants were aged between 25 and 59 years. The majority ( $n = 16$ ) of the participants were based in Australia, and six were based in the United Kingdom, all based in England. Experience ranged from 2 to 30 years postregistration, and the average experience was 12.9 years. Hospital specialty practice included cardiothoracics, paediatrics, obstetrics and gynaecology, gastroenterology, infectious diseases and geriatrics.

All participants ( $n = 22$ ) reported having provided nutrition advice in medical practice, though the reported frequency varied considerably from 'every day' to 'once every 3 months'. Nearly all participants reported providing brief and general advice for a range of conditions, most of which were chronic, and very few participants reported providing general healthy eating advice. The most frequently mentioned conditions for which participants reported provision of nutrition advice include hypercholesterolaemia, diabetes and management of frailty in the elderly. Hospital-based doctors generally reported providing nutrition advice in the context of their specialty; for example, an endocrinologist described giving dietary advice in the context of a diabetes clinic. Most hospital-based doctors reported providing nutrition advice only if their patients had broached the topic or had questions. Few participants reported individualising the nutrition care provided, although it was acknowledged that this was an element of optimal nutrition care. Confidence to facilitate nutrition care was highly variable among participants, but even those most proactive about providing nutrition advice acknowledged limitations to their nutrition-related knowledge and skills.

TABLE 1 Interview questions and inquiry logic

Interview questions	Inquiry logic
Have you ever provided nutrition information as a medical practitioner? Probe: <ul style="list-style-type: none"> <li>– If so, what for?</li> <li>– What information did you provide? (i.e., was the information general or individualised?)</li> <li>– Did you feel confident to provide this advice?</li> <li>– Do you regularly provide nutrition advice in practice?</li> <li>– If so, how many times per week or month (on average) do you provide nutrition advice in practice?</li> </ul>	Explore scope and regularity of dietary advice provided by medical practitioners to identify patterns of nutrition care in medical practice.
What do you think is your role in nutrition care?	Explore perceptions of nutrition-related scope of practice in medical care.
What are the barriers to providing nutrition care?	Identify barriers to the provision of nutrition care in practice.
What is changing or likely to change in the profession that might affect the delivery of nutrition care in practice?	Identify changes in service delivery and future work roles related to the provision of nutrition care.
Can you describe an incident/example where you wanted to provide advice or had a request from a patient and were unable to provide this advice?	Discussion of critical incident to provide insights into deficits.
Specifically, what knowledge, skills and attitudes do you think you need to provide nutrition care to patients? Probe: <ul style="list-style-type: none"> <li>– Do you think there is enough information on nutrition in your training/education?</li> <li>– As a medical student?</li> <li>– In specialist training?</li> <li>– In ongoing training (i.e., CPD)?</li> <li>– Do you think the knowledge, skills and attitudes you require to provide nutrition care vary from other medical providers?</li> <li>– If so, how and why?</li> </ul>	Identify nutrition knowledge, skills and attitudes required to provide nutrition care and delineation of competencies across the medical continuum (if any).
What do you think are the gaps in the current level and scope of nutrition care provided by medical practitioners? Probe: <ul style="list-style-type: none"> <li>– Based on your experience, what is the likelihood that GPs will have provided dietary counselling to patients before they are referred for specialist treatment?</li> <li>– How do you think these gaps should be addressed?</li> </ul>	Identify gaps in medical nutrition competency and proposed solutions.
Is there anything you would like to add?	

Abbreviations: CPD, continuing professional development; GP, general practitioner.

Framework analysis identified five key themes: (1) knowledge and skills in nutrition to support medical nutrition care, (2) the delivery of nutrition education, (3) multidisciplinary education and care, (4) systemic barriers to care and positive disruptors and (5) the need for a paradigm shift. These themes are described later, with illustrative quotes provided to aid interpretation, where GP refers to general practitioner and S refers to specialist.

### Knowledge and skills required to support medical nutrition care

Participants suggested that a range of knowledge and skills were required to support individual nutrition care

of patients, with the most salient being knowledge of evidence-based dietary interventions for the prevention and management of noncommunicable disease, which participants reported as the most frequent opportunity to provide nutrition intervention in practice.

Participants identified nutrition assessment and onward referral of at-risk patients as key skills to support nutrition care in both primary and secondary care settings. Therefore, knowledge of referral pathways and access to dietetic services were also identified as relevant in this context. Communication skills emerged as a supporting competency for broad medical care, to build rapport with patients, and in the context of nutrition, behaviour change skills such as motivational interviewing were identified as fundamental to the

delivery of nutrition education. Participants also identified a need for critical thinking skills, to appraise nutrition research and identify credible sources of nutrition information. GPs, in particular, emphasised the skill to be able to locate and access evidence-based resources in a timely fashion in practice. Finally, participants emphasised their role in person-centred care, which emerged as an underlying, cross-cutting philosophy for effective care. In the context of nutrition, participants emphasised being able to tailor the message to individuals and their level of understanding, including knowledge of nutrition requirements across the lifespan and awareness of the socio-cultural determinants of health. A full list of nutrition knowledge and skills identified in this study are provided in Supporting Information: Supplementary Materials.

So, it's really being able to do a brief assessment, and it's really being able to spot and identify the patients, could benefit from a further, more in-depth assessment ... tailoring it to your patient and being aware of what nutritional barriers that are in different populations. (GP11)

I think, you know, we're taught how to sort of critically appraise at medical school, but ... I think nutrition is a completely different space. So, research skills within sort of nutrition space, I think, would be really helpful. (GP14)

I think just knowing limitations, when to refer. (S2)

## The delivery of nutrition education

Most participants in this study reported a lack of nutrition education in medical training at all levels, including medical school; throughout hospital placements; and in GP and specialist education, including assessment. They indicated that there was a need for more nutrition education, with some disparity regarding where and when nutrition education might be delivered. Some agreed that nutrition education in medical school is important, in order for nutrition to be perceived as relevant to individual care from the outset of training. One participant felt that faculty would continue to neglect nutrition unless it was taught as a distinct course and suggested 'protected' time for nutrition education in medical school. In contrast, some GPs felt that undergraduate nutrition education was not suitable as it may not be relevant to all areas of practice. Some participants felt that exposure to nutrition education should focus on application to practice at the postgraduate level. Irrespective of where nutrition might sit in education,

participants were able to identify that to raise the profile of nutrition as relevant to medical practice, it needed to be assessed. They supported a multidisciplinary approach to nutrition education, specifically that the delivery of nutrition education would be enhanced by input from dietitians.

You might have done a short module on nutrition and ... that would be one which everyone would skim over, because we knew that it wouldn't be examined that rigorously in the exam, because the people who were setting the exam weren't dietitians, they would be medics. (GP7)

Yeah, I mean, it'd be dietitians delivering it? Yeah. And obviously, you could have, like a medical input, or commentary, as well as it [nutrition education] could be a co delivery.... I think doctors would want to hear from the dietitian, because, I mean, if we hear from other doctors, they're going to say the same things over and over. (GP1)

Participants identified continuing professional development (CPD) as a common and relevant place for nutrition education. However, there was a perception that those interested in nutrition would seek it out as an adjunct to any formal nutrition education. Some noted that nutrition would continue to be overlooked unless ongoing CPD in nutrition was required rather than just an optional add-on for those specifically interested in nutrition.

Certainly have to be continuing medical education, because this [nutrition evidence] is going to obviously, continuously evolve as knowledge changes about the individual areas. (GP7)

## Multidisciplinary and interprofessional care

When participants were asked about their role in the provision of nutrition care, there was variation as to whether or not doctors thought it was within their remit. Doctors in primary care acknowledged that they are likely the first point of contact for patients in the healthcare system and felt they were well placed to provide an initial assessment and brief advice. The majority of participants perceived their role in nutrition care as complementary to other healthcare professionals, such as dietitians. Many GPs emphasised their role in the co-ordination of health services. All participants, including those with an interest in nutrition, acknowledge that they need specialist assistance at times and identified onward referral as central to their role in nutrition care.



In terms of confidence, probably dietitians are more well placed in terms of their training to have the specific details but in terms of accessibility, patient liaison, community engagement, definitely the GP, and that's why GPs do so much of everything. (GP2)

Access to dietetic services was important from the perspective of GPs, who acknowledged that they were more likely to refer to a dietitian if they were available at practice and felt that this health service model might encourage better care. Particularly among hospital-based doctors, there was a general consensus that team-based care is important in the delivery of nutrition care. In particular, it was acknowledged that nutrition crosses over with medicine in achieving outcomes and perceived multidisciplinary and interprofessional care as essential.

I don't think any of the practices I've ever worked at have had a dietitian, but I think it'd be a game changer ... it just really allows you to deliver holistic care, you know, instead of sort of just the, fobbing off a patient, and giving some blanket statement advice, you can actually, you know, hook them in with a specialist who can give them the relevant file. (GP14)

As surgeons, we do recognise the importance of nutrition, but we also recognise that there may be deficiencies in knowledge and certain subspecialties. And to cover for that, the, we've introduced these multidisciplinary approaches. (S8)

### Systemic barriers and facilitators to nutrition care

Participants from the United Kingdom and Australia identified systemic barriers that limit nutrition care, in particular consultation time as a common barrier, recognising that providing advice regarding nutrition may take longer than the typical appointment times. In particular, some participants reported consultation time as limiting in terms of being able to build rapport with patients, which they identified as important in the delivery of person-centred care. Interestingly, some specialists felt they had more time in a consultation than a GP to provide nutrition advice.

In my world, which is the world of an NHS, UK GP, that the single biggest barrier is time ... if you're going to do the job properly with, you know, dietary advice, it takes a bit longer than a, you know, a 10-minute

appointment. So that's the biggest barrier. (GP13)

Although participants acknowledged the need to refer at-risk patients to a dietitian for specialist care, they also noted barriers to referral, such as the availability of local dietetic services, patient motivation and cost of a private practitioner for patients living in a low-socio-economic area. Both primary care doctors and those in other specialties identified health service limitations to the nutrition care that can be delivered in the context of primary care. Participants from Australia acknowledged limitations to Medicare GP Care Plans with regard to funding and also noted similarities between Medicare and the UK National Health System (NHS). In particular, the criteria or the number of allowed visits was problematic. Participants working in secondary or tertiary care also identified health service limitations to the nutrition care they can provide. In some cases, GPs were less inclined to offer referral to a dietitian if they had experienced rejection of referral by patients frequently or if they felt that the dietitian disagreed with their own dietary advice.

But you've only got five visits a year for a patient with a chronic or complex condition. And so, you're balancing that against other things that the patient might need to so some of it's got to do with access, as well. So, it's not balanced with the patient's clinical needs.... I may well refer patients more frequently if access was easier. (GP8)

Working in a lower socio-economic area, I think that people are less inclined to accept it [referral to a dietitian]. And because I'm getting knocked back more often then you're just less inclined to offer it as often. (GP5)

Possible solutions such as increased funding from government or being able to charge for nutrition counselling would encourage more nutrition advice in practice. Participants perceived technology as a positive disruptor, in both an acute care context and primary care. In particular, participants highlighted that telehealth could be leveraged to deliver health promotion education, such as nutrition advice, facilitate better access to dietetics services and encourage more multidisciplinary care.

So, oddly enough, one of the things that would make a difference would be a bit more Medicare funding specifically for that. ... If I actually had, you know, requirement in the CPD or in Medicare, for us to have done a certain amount of nutrition training, and then be able to access higher numbers for

your nutrition advice, then I think that would work. (GP3)

### The need for a paradigm shift

Some participants identified a focus in practice on secondary and tertiary healthcare and attributed this to medical education being based on the medical model, which suggests that disease is detected, identified and treated. Although acknowledging the relevance of nutrition to medical care, participants typically did not consider preventive nutrition, rather only broaching the subject once a disease or a condition is present. Some participants acknowledged that it was easier and saved time to prescribe medications than provide dietary advice and that there are gaps in competency related to preventive aspects of nutrition care, such as weight management and general healthy eating. Participants identified the need for medical education to focus on preventive healthcare in general, including nutrition, and felt that this would help the profession to embrace health promotion and disease prevention as part of their role and, by proxy, nutrition care. Only one practitioner acknowledged preventive healthcare in the context of nutrition but noted that this was likely a different perspective from other medical colleagues.

I think most of what we were taught were based on the medical model ... pathological type model is basically geared towards certain conditions, management includes dietary advice ... getting people to think more about the health promotion, in a ... more global model of health, that could actually result in doctors taking dietary things more seriously.... I think it does require a bit of a paradigm shift. (GP1)

Our training focuses much more on pharmaceuticals and ... surgical procedures as interventions rather than dietary advice. (GP7)

When we churn out junior doctors, they're sort of obsessed with the diagnosis, treatment, prescribing medicines, but there's a bit more to it.... I think that would improve if the wider profession embraced nutrition more. (S8)

In the medical profession, there is a culture that generally discredits diet or doesn't include it in medical advice, especially in hospital.... I think once someone's in

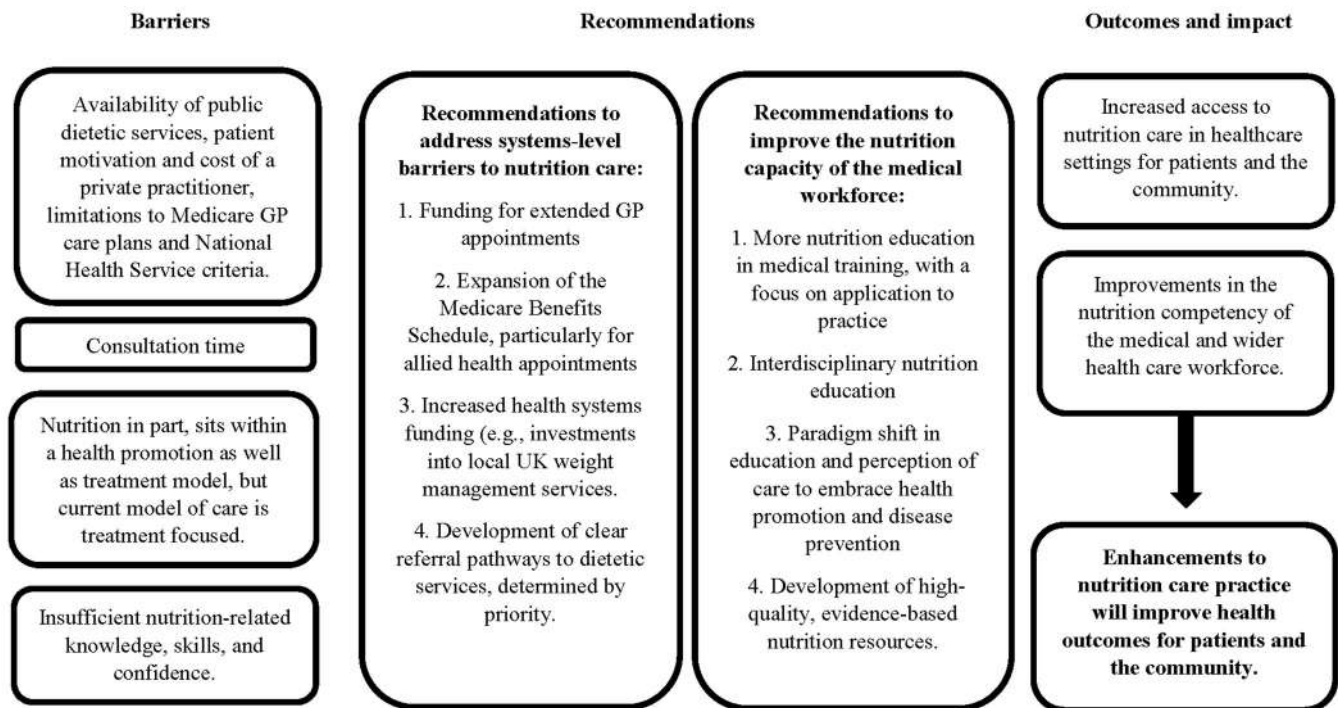
hospital, one big barrier to talking about diet is that the medications are far easier to prescribe and quicker to explain, generally. (S2)

## DISCUSSION

Doctors from the United Kingdom and Australia working in primary and secondary care were able to clearly articulate barriers and facilitators in the provision of nutrition care. Although they generally recognise the importance of this care, they understand that in many ways they are ill-equipped to provide nutrition care due to limitations in their knowledge but also in relation to the systems that might inhibit the provision of integrated care. Finally, they further identify that nutrition sits within both a health promotion and a treatment model of care but that as clinicians they tend to work only within a treatment model.

The themes identified in this study confirm the need for a shift towards a preventative model of care to promote effective, team-based nutrition care in practice. This might be cultivated by enhanced nutrition education for medical and healthcare professionals to support capacity building in nutrition and wider health systems funding to facilitate the integration of nutrition into healthcare settings. Figure 1 provides a visual representation of the relationship between key themes identified from interview data, including the outcomes and impact of recommendations outlined in the discussion, based on implementation guidance.

Multidisciplinary care is the cornerstone of optimal, patient-centred care and has been shown to improve health outcomes.<sup>25,26</sup> Participants in this study perceived their role in nutrition care to be complementary to other health professionals. Doctors working in primary care, in particular, acknowledged that they are well placed to initiate the conversation about diet and to arrange a referral for others to provide this service. This is consistent with findings from previous authors who report that Australian GPs perceive their nutrition care role as coordinators of patient care, enacted by arranging referrals to dietitians.<sup>27,28</sup> Medical students and doctors in the United Kingdom also acknowledge the importance of a collaborative approach to nutrition care.<sup>29</sup> In Australia in 2015–2016, the treatment and management of patients living with noncommunicable diseases was responsible for 80% of GP visits.<sup>30</sup> Nutrition is a feature of up to a quarter of all GP visits, and patients with conditions that are manageable with dietary interventions consult a GP more than average.<sup>31</sup> Yet utilisation of the Medicare Benefits Scheme Chronic Disease Management item for case conferences remains low.<sup>32,33</sup> Furthermore, in an Australian study, Mulquaney et al. (2018) reported that of 145,708 consultations by registrars, only 528 (0.26%) resulted in a referral to a dietitian, and in 2015–2016,



**FIGURE 1** Key recommendations and their outcomes and impact from 22 interviews with Australian and UK-based primary care doctors/general practitioners ( $n = 14$ ) and other medical specialists ( $n = 8$ )

GP referrals to dietitians constituted only 9% of all allied health referrals in Australia.<sup>6,34</sup> It has been previously reported that GPs who have received nutrition training refer their patients more often to a dietitian, suggesting that increased training in nutrition may promote a more team-based approach to nutrition care in practice.<sup>35</sup> Individuals with diet-related noncommunicable disease experience better outcomes when they have access to primary healthcare provided by a multidisciplinary team, including a GP and one or more allied health practitioners.<sup>36</sup> Moreover, increased use of dietetic services can significantly reduce GP workloads, a pervasive barrier to the feasibility and adequacy of nutrition care in this context. For example, patients with irritable bowel syndrome who received dietetic-led interventions in primary care reported improvements in long-term symptoms that may result in reduced visits to a GP.<sup>37</sup> This may suggest that current medical education does not adequately prepare doctors to provide dietary advice or promote the use of suitable multidisciplinary care models, such as those that might include referral for specialist dietetic care. A clear referral pathway determined by priority accompanied by a shift away from treatment-focused care to preventative care may also necessitate more multidisciplinary care in practice.

The concept of collaboration between doctors and dietitians was highlighted as important in nutrition education but also in person-centred care. Participants in this study believed their nutrition education could be enhanced by input from a nutrition professional, such as

a dietitian, in line with literature which identifies limited collaboration with nutrition professionals as a barrier to adequate medical nutrition education.<sup>38</sup> In addition, there is evidence that dietitians, as experts in nutrition, perceive themselves as the most appropriate professionals to administer this education, want to teach nutrition to medical students and express confidence in their ability to do so.<sup>39</sup> This echoes the position of the Academy of Nutrition and Dietetics, which supports interprofessional education (IPE) in nutrition as an essential component of medical education.<sup>25</sup> Furthermore, interprofessional approaches to nutrition education promote the perception of the role of the medical profession in a multidisciplinary approach to nutrition care, including recognition of when a referral to another health professional is required, such as a dietitian, who is able to provide specialised nutrition advice.<sup>13,25,40</sup> IPE is defined by the World Health Organization (WHO) as *when students from two or more professions learn about, from and with each other, to enable effective collaboration and improve health outcomes*, and is now a common requirement in health professions curricula.<sup>41</sup> IPE has been shown to promote team-based care, is linked with positive outcomes for patients and has been shown to lead to significant improvements in the interprofessional competencies for undergraduate medical students.<sup>42–45</sup> For example, in one study, first-year medical students received a 1-h lecture on how to perform a dietary history and nutrition counselling, then had the opportunity to role-play with each other to practice these skills, with

feedback from dietetics students.<sup>42</sup> There was an increase in confidence with nutrition counselling, and 74% of medical students found working with dietetics students to be helpful or extremely helpful.<sup>42</sup> Nutrition professionals may have an important role in championing the integration of nutrition into medical education and may also be part of education in the preregistration setting.

Although the need for enhanced medical nutrition education for capacity building is not to be dismissed, there are clear, systemic limitations to the care that can be provided. Doctors working in primary care are busy 'fire-fighting' the consequences of noncommunicable disease, and consultation time represents a standing barrier to nutrition care.<sup>14,46,47</sup> The duration of the average GP consultation time in Australia is just 15 min and in the United Kingdom 10.6 min.<sup>6,48</sup> Yet it is the norm for Australian GPs to manage multiple (three to four) problems per consultation, and there is an increasing demand for care internationally.<sup>6,48</sup> For example, the WHO estimates that by 2050, 2 billion people will be aged 60 years and older.<sup>49</sup> The older population has specific nutritional needs, as identified by participants in this study.<sup>50</sup> The pooled prevalence of malnutrition in the older community setting is estimated to be almost 25% in some countries, and age is a major risk factor for noncommunicable diseases such as chronic obstructive pulmonary disease, cognitive decline and dementia, all of which increase demand on primary healthcare.<sup>50,51</sup> One recommendation to improve the ability of primary healthcare to meet this demand is to increase funding for extended GP consultations, as recently advocated for by the Royal Australian College of General Practitioners (RACGP) and the British Medical Association (BMA).<sup>52,53</sup>

Although extended consultation times would increase the likelihood that primary care providers can engage with nutrition care, it does not negate wider health system limitations, such as chronic underfunding and ongoing staffing and resource shortfalls, which greatly impact on the ability of doctors to provide meaningful nutrition advice to their patients. For example, in Australia, there are 0.03 dietitians per 1000 people, and in the United Kingdom, the number of dietitians to doctors in the health service is 3 per 100.<sup>54</sup> In the absence of dietetic services, GPs commented that the provision of evidence-based resources to patients would be another model to provide nutrition education. In the National Health Service England, government funding for local authority public health budgets has been substantially reduced in recent years and was 22% lower in real terms in 2020–2021 compared with 2015–2016.<sup>55</sup> Furthermore, doctors with a higher percentage of privately insured patients are more likely to provide adequate nutrition care.<sup>56</sup> Given these systemic limitations, there is a need for broader health systems funding to keep pace with the need for these services and clear referral pathways to improve access to preventative care in the public health system, including dietitians. In Australia, funding to

support expansion of the Medicare Benefits Schedule has been previously recommended.<sup>57</sup> In particular, there have been calls to increase the number of allied health appointments under team care arrangements (items 721 and 723) and introduce initial assessment appointments of more than 40 min for allied health professionals.<sup>57</sup> In England, the British Dietetic Association advocates for increased government investments in local weight management services.<sup>58</sup> Investment from preventative interventions creates wider economic, social and personal value and provides a means to moderate demands on the health system, by ideally managing healthcare needs in the context of primary care to prevent, defer or reduce demands on secondary and tertiary sectors.

In this study, many participants did not consider the role of nutrition in health promotion and disease prevention and emphasised noncommunicable disease diagnosis or a patient request as a prompt to initiate nutrition care, the latter of which is the most common trigger for the initiation of nutrition care in general practice.<sup>59</sup> Sims et al. noted that Australian GPs did not view health promotion programmes as worthwhile and found it difficult to adopt a social model of health.<sup>60</sup> Patients who may benefit from nutrition care may be missing out, and this may suggest that doctors require a broader understanding of opportunities for patient nutrition management. In practice, screening rates for preventive services are considerably lower than ideal, and rates for preventive counselling in primary care remain low in Australia and the United Kingdom.<sup>61–63</sup> Yet taking a prescription or nonprescription medication is the most common health activity among Australians, and over two-thirds of doctor visits involve recommendations about medication.<sup>6,64</sup> Interestingly, this may have something to do with favouring the traditional medical model, whereby doctors feel a duty to prescribe care rather than permit patients to share decision-making.<sup>65</sup>

A key theme from interview data was the need for a paradigm shift in medical education and practice. Medical education is historically focused on disease, diagnosis and drugs, and there is not yet a prevalent-enough thread that nutrition is a key, and effective, component of medical care.<sup>13,66</sup> It is the position of the Academy of Nutrition and Dietetics that primary prevention is the most effective method to prevent noncommunicable disease.<sup>3</sup> The Australian National Preventive Health Strategy 2021–2030 confirms the role of preventive healthcare in addressing the increasing burden of disease.<sup>67</sup> The EAT-Lancet Commission framework and Universal Health Coverage also emphasise preventive health measures, as part of the full range of essential health services.<sup>68,69</sup> Yet health promotion and, by proxy, nutrition remain deprioritised in medical education.<sup>13,22,62,66,70</sup> There is an opportunity to synergise medical education with the unmet potential for health promotion and disease prevention in the context of medical care. Medical education must prioritise the preservation of health and prevention of disease and, equally, provide the



opportunity to translate health promotion concepts into skills for clinical practice. Interventions which improve medical students' health habits and behaviours, for example, the Cooking for Optimisation of Health Initiative, have been shown to improve competency in nutrition and personal dietary behaviour, a predicting factor in the likelihood that a doctor will counsel patients about lifestyle habits.<sup>71</sup> No matter the curricular intervention, to incentivise the inclusion of nutrition in medical education, we have previously recommended that nutrition is embedded within relevant regulatory frameworks to ensure implementation.<sup>22</sup>

## STRENGTHS AND LIMITATIONS

A strength of this study is that it considers the perspective of doctors working across the continuum of medical care. However, the relatively small sample ( $n = 22$ ) might be considered a limitation. This study was also limited to participation from individuals living in Australia and the United Kingdom, and caution must be exercised against generalising these results. Finally, it is important to note that there are differences between Australia and the United Kingdom in terms of the healthcare system and population size, which may impact key points from each of the professionals. However, our results noted few differences other than specific funding systems between the two countries. Two of the researchers were dietitians, and this may have influenced the interpretation of the data to prioritise nutrition care as a solution in healthcare although a third (nonpractitioner) researcher also provided duplicate analysis. Online interviews may have limited some review of body language, but this format facilitated opportunities to recruit practitioners from a broad geographical area. Future studies could also examine the differences between GPs and other medical specialists in perceptions of work roles in the delivery of nutrition care and the knowledge, skills and attitudes required to support such care.

## CONCLUSION

Practitioners recognise that they need knowledge and skills to provide nutrition care, yet they identify that nutrition remains deprioritised in medical education and clinical care. There are systemic barriers to the provision of nutrition care; thus, any efforts to improve the nutrition capacity of the medical and wider health workforce must be matched by increased investments in primary prevention, including nutrition. Capacity development requires a paradigm shift in medical education and perception of care to emphasise health promotion and disease prevention and, by proxy, nutrition.

## AUTHOR CONTRIBUTIONS

Breanna Lepre, Eleanor J. Beck and Kylie J. Mansfield contributed to the design of the study. Breanna Lepre

and Eleanor J. Beck contributed to data collection. All authors contributed to data analysis. Breanna Lepre drafted the manuscript. All authors contributed to the revision of the manuscript and approval of the final manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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## CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the Supplementary Material of this article.

## ETHICS STATEMENT

The University of Wollongong Human Research Ethics Committee approved this study (protocol number: 2020/062).

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The Standards for Reporting Qualitative Research (SRQR) guideline was used to guide the reporting of this study.

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## PEER REVIEW

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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# Co-designing nutrition interventions with consumers: A scoping review

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## Abstract

**Background:** There is little known about nutrition intervention research involving consumer co-design. The aim of this scoping review was to identify and synthesise the existing evidence on the current use and extent of consumer co-design in nutrition interventions.

**Methods:** This scoping review is in line with the methodological framework developed by Arksey and O'Malley and refined by the Joanna Briggs Institute using an adapted 2weekSR approach. We searched Medline, EMBASE, PsycInfo, CINAHL and Cochrane. Only studies that included consumers in the co-design and met the 'Collaborate' or 'Empower' levels of the International Association of Public Participation's Public Participation Spectrum were included. Studies were synthesised according to two main concepts: (1) co-design for (2) nutrition interventions.

**Results:** The initial search yielded 8157 articles, of which 19 studies were included (comprising 29 articles). The studies represented a range of intervention types and participants from seven countries. Sixteen studies were published in the past 5 years. Co-design was most often used for intervention development, and only two studies reported a partnership with consumers across all stages of research. Overall, consumer involvement was not well documented. No preferred co-design framework or approach was reported across the various studies.

**Conclusions:** Consumer co-design for nutrition interventions has become more frequent in recent years, but genuine partnerships with consumers across all stages of nutrition intervention research remain uncommon. There is an opportunity to improve the reporting of consumer involvement in co-design and enable equal partnerships with consumers in nutrition research.

## KEYWORDS

co-design, consumer engagement, diet, nutrition intervention, participatory research

## Key points

- Of the approximately 5000 abstracts screened, only 19 studies met the criteria of co-design at the 'Collaborate' or 'Empower' levels of Public

Anna Mae Scott and Susan de Jersey are co-senior authors.

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- Participation (IAP2 Public Participation Spectrum), and there is high variability in co-design approaches and definitions within health research.
- Similarly, there is no singular co-design framework or theoretical approach that is commonly used, although intervention mapping and integrated knowledge translation approaches were most common.
  - Co-designing dietary interventions typically occurs after a research question and direction has already been predetermined, and often, researchers 'override' consumers' recommendations and decisions.
  - Our scoping review included a consumer as a co-author, which was a strength of this paper. Based on our consumer co-author's recommendation, we developed an 'ideal co-design' checklist to capture key elements of co-design that should be considered in research projects – about one quarter of included studies met all or most of these elements.
  - Although co-design for dietary interventions has become more common in the past 5 years, consumers are rarely engaged across the entire research process, which could help improve research impact and reduce research waste.

## INTRODUCTION

Non-communicable diseases are the greatest contributors to poor health and mortality.<sup>1</sup> Globally, cardiovascular diseases are the leading cause of death,<sup>2</sup> with dietary risk factors the most important contributor to disease burden.<sup>1</sup> Consequently, nutrition interventions aiming to improve dietary behaviours and optimise dietary patterns are a key strategy to prevent and manage poor health.<sup>3</sup>

Although research has demonstrated that nutrition interventions are effective in trial settings,<sup>4</sup> influencing dietary behaviour is complex, with economic, social, environmental and physiological determinants.<sup>5,6</sup> Dietary behaviour changes after nutrition interventions are broadly positive, particularly fruit, vegetable and fat intake.<sup>3</sup> However, these changes are inconsistent across population groups,<sup>3</sup> and long-term adherence to behaviour changes appears challenging.<sup>5</sup> Person-centred care is a paradigm which recognises the uniqueness of individuals and the necessity of healthcare providers and organisations to partner with consumers (and carers) in shared decisions about healthcare and services.<sup>7</sup> Failing to incorporate consumers' shared values, preferences and priorities through person-centred care is likely to limit the effectiveness of healthcare, including nutrition interventions in the short and long term.

Consumer engagement and co-design in healthcare is increasingly being recognised as essential from the outset of planning for any improvement or research programme, due to its potential to align health services with consumer needs, and improving uptake and engagement with healthcare. Furthermore, inclusion of consumers in research is considered morally/ethically necessary, politically justified (in terms of developing policy and allocating funding) and methodologically beneficial (to improve relevance and transferability of research

findings).<sup>8</sup> In the context of health and medical research, several definitions of a consumer exist, with most encompassing any or all of the following: (a) a patient (person who is receiving care in a health service organisation); (b) a person who has used, or may potentially use, health services or is a carer for a patient using health services; or (c) a consumer representative (person who provides a consumer perspective; contributes consumer experiences; advocates in the interests of past, current and potential health service users; and takes part in decision-making processes).<sup>9</sup> For this review, the term 'consumer' encompasses all these definitions.

The definition of co-design (and other related 'co-words' such as 'co-production', 'co-creation', 'co-development' and 'co-construct') has been a topic of debate, with a recent scoping review identifying 475 unique definitions used for co-design and co-production.<sup>10</sup> Generally, definitions refer to co-design as a participatory approach that engages all potential end users (e.g., service providers and service users) to design something of 'value' (context dependent),<sup>11</sup> whereas others include the quality of these relationships through principles such as equity, power and trust.<sup>10</sup> Following recent work by two authors (consumer, A. C., and researcher, A. Y.) that included extensive involvement of a broad range of health service consumers, clinicians and researchers and recognising the importance of equity and partnerships,<sup>10,12,13</sup> a 'co-designed' definition is proposed in this review to emphasise the importance of relational considerations within co-design. Here we define co-design as 'a process where people with professional and lived experience partner as equals to improve health services by listening, learning and making decisions together'.<sup>14</sup> The International Association of Public Participation (IAP2) describes the participation of consumers as a spectrum ranging from 'Inform' through 'Empower'<sup>15</sup> (Table 1). It has been designed to provide



**TABLE 1** Level of public participation according to the IAP2 Public Participation Spectrum<sup>15</sup> required to be included in the scoping review

IAP2 level	Public involvement goal	Example	Included
Inform	To provide the public with balanced and objective information	Notifying consumers about the availability of a new nutrition intervention	χ
Consult	To obtain public feedback on analysis, alternatives and/or decisions	Conducting a needs assessment or focus groups with consumers, led by a research team	χ
Involve	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered	Consumers involved in an advisory committee for a research project	χ
Collaborate	To partner with the public in each aspect of the decision, including the development of alternatives and the identification of a preferred solution	Consumers making decisions about the design and execution of a research study as part of the research or design team	χ
Empower	To place final decision-making in the hands of the public	Consumers leading the decision-making process about what to research and how to do it, with help from the research team	χ

Abbreviation: IAP2, International Association of Public Participation.

clarity to consumers and professionals about the different levels of consumer participation and to assist in selecting the appropriate level for the goals of engagement activity and setting expectations about the role of the consumer and professional.<sup>15</sup> When considered within this spectrum, co-design sits within the ‘Collaborate’ and ‘Empower’ levels<sup>15</sup> (Table 1).

Due to the complexity of behaviour change,<sup>5,6</sup> interventions focused on improving nutrition and health behaviour are likely to benefit from co-design due to the aforementioned reasons; however, little is known about the extent to which consumer co-design is incorporated into nutrition interventions and how this impacts outcomes. A recent integrative review of co-design practices in diet and nutrition research sought to describe the use and effectiveness of techniques that involve consumers in nutrition research across the engagement spectrum.<sup>16</sup> Only three of the included studies<sup>17–19</sup> reached ‘collegiate’ levels of participation, defined as ‘researchers and local people work(ing) together as colleagues with different skills to offer, in the process of mutual learning where local people have control over the process’.<sup>16</sup> Furthermore, key co-design studies were not included in the review,<sup>20–24</sup> and due to the rapid increase in co-design studies, even in the past 2 years, we have identified several recent studies that considerably add to the literature involving co-design for nutrition interventions.

Mapping out where and when co-design has been used in the design, application and evaluation of nutrition interventions is essential to guide future use of co-design in nutrition research, to ensure that it is transformative rather than being tokenistic.<sup>25</sup> An important consideration for future reviews on co-design is the inclusion of consumers in the review itself. There are strong arguments for involving consumers in systematic and scoping reviews, particularly as reviews are often used to drive practice and policy changes.<sup>26–28</sup>

Involvement of consumers in systematic reviews has also been poorly reported, but studies have reported improved relevance of data extraction, synthesis and dissemination of key messages from the review.<sup>27,29</sup> A lack of inclusive priority setting from evidence synthesis through the absence of end user engagement can result in a mismatch between research delivered and health service needs and priorities and is ultimately a financial and time waste.<sup>30</sup>

The aim of this scoping review was to synthesise the current use and extent of consumer co-design in nutrition interventions. Here we choose to focus on the methods and theoretical approaches to co-design rather than the effectiveness of nutrition interventions, opting for a scoping review over a systematic review.

## METHODS

### Approach

This scoping review was conducted based on the methodological framework developed by Arksey and O'Malley<sup>31</sup> and refined by the Joanna Briggs Institute<sup>32</sup> using an adapted 2weekSR approach.<sup>33</sup> It is reported in compliance with the PRISMA-ScR reporting guideline.<sup>34</sup> In the spirit of co-design and recognising the need for genuine inclusion of patient and consumer perspectives in research and evidence synthesis,<sup>27,35,36</sup> we have included an experienced consumer (A. C.: current active user of the health system, person with lived experience, consumer representative and research co-lead) as part of the scoping review team. The aim of involving a consumer in the review was to allow a collaborative definition of co-design and the assessment of its application within the included studies. This involved the consumer's attendance at all team meetings, including a pre-review meeting about the role, time commitment,



payment and acknowledgement. The Guidance for Reporting Involvement of Patients and the Public-Short Form (GRIPP2-SF)<sup>37</sup> was developed to enhance the quality and consistency of reporting consumer engagement in research studies and was used when preparing this manuscript due to the inclusion of a consumer in this research. The protocol for this review was developed prospectively and is available at <https://osf.io/dka3m/>. Deviations from the protocol are reported in the relevant methods section.

## Study eligibility criteria

This review aimed to find, assess and synthesise all study types that used co-design for nutrition interventions delivered within a healthcare, community or academic setting. We included any type of primary study (qualitative or quantitative) with any sample size. Eligible studies are detailed under participant, concept and context.

## Participants

Eligible studies must have included consumers (persons with lived experience; their caregivers; past, current or future users of healthcare; or consumer representatives) as participants in the co-design team. The co-design team will also have included other stakeholders (e.g., healthcare workers, researchers or decision-makers), but we excluded articles that were co-designed only with these stakeholders, exclusively. We included studies with participants of any gender, geographic location or health status. Co-design undertaken with children or adolescents below 16 years was excluded.

## Concept

We included two concepts: (1) co-design of (2) nutrition interventions with stakeholders. For the scoping review, co-design is defined as a ‘process where people with professional and lived experience partner as equals to improve health services by listening, learning and making decisions together’. This definition was developed by authors A. Y. and A. C. after extensive engagement of consumers, health professionals and researchers (total  $n = 120$ ) undertaking co-design in research and health service improvement (manuscript in preparation). We included articles that applied co-design to any of the following research stages in relation to nutrition intervention: determining research need, direction or questions (co-decide); planning and study design (co-plan); design of the intervention (co-design intervention); evaluation (co-evaluate); and dissemination (co-disseminate) or implementation (co-implement).

To be eligible, the consumer activities must have fit within the ‘Collaborate’ and ‘Empower’ levels from the IAP2 (Table 1).<sup>15</sup> Nutrition intervention could be for any health condition or dietary behaviour. However, nutrition interventions that improved food access (i.e., by focusing on food security) were not included in recognition that this addresses factors separate from the focus of this review. Mixed interventions (that include other components such as physical activity) were included provided the dietary component was included in the co-design process.

This included the following:

- Co-design to formulate the intervention purpose and research questions
- Co-design when described for the design/development of a nutrition intervention
- Co-design in complex or multi-component interventions that include a nutrition component

We excluded the following:

- Formative research conducted with consumers to set a direction for future research recommendations or policy decision-making generally (not focused on a specific intervention or future research to be conducted by the team)
- Studies that mentioned co-design without describing the included participants or a shared partnership co-design process
- Consultation with consumers (through any methods) to adapt, test or pilot an intervention that does not meet the IAP2 levels of ‘Collaborate’ or ‘Empower’
- Co-design of food products (for retail/wholesale) or its packaging
- Co-design of agricultural or food systems (not relating to a nutrition intervention)
- Co-designing solutions to food access or food security (individual's behaviour rather than environment)
- Conceptual development of a co-design process, including proposed frameworks that have not been applied to co-designing a nutrition intervention
- Studies where the purpose of consumer engagement was to explore barriers and enablers (in general) to nutrition-related behaviour change or perceptions/acceptability of an intervention
- Nutrition interventions targeted at children and adolescents (up to age 15 years).

## Context

Included studies were set in any healthcare, community or academic setting from any country. We included studies that were peer reviewed; had a quantitative, qualitative or mixed-methods study design; or were study

protocols that detailed co-design as part of the intervention development or to set the direction of the research questions of interest. We excluded review articles, grey literature and non-peer-reviewed publications, including theses and published conference abstracts. Systematic/scoping reviews that directly covered co-designed nutrition interventions but no other concepts about co-design were excluded, but their lists of included studies were searched for any additional studies meeting the inclusion criteria of the present review.

## Search strategy

We designed the search strategy as follows: three study authors (N. M., A. R. and A. M. S.) identified three key concepts (diet, co-design and stakeholders) for the search and generated a preliminary list of search terms for each concept based on clinical expertise (N. M. and A. R.). We then conducted a word frequency analysis using the Word Frequency Analyser<sup>33</sup> on the titles, abstracts and keywords of three articles which were considered potentially includible,<sup>24,38,39</sup> and we considered for inclusion the terms identified by the Word Frequency Analyser by consensus. The search strategy was drafted for Medline (PubMed), consulted with the entire author team, and further refinements were made. One author (A. M. S.) then tested the strategy in Search Refinery<sup>33</sup> to ensure it identified the three potentially includible references and used Polyglot Search Translator<sup>33</sup> to translate the strategy for other databases. The search strategy was intentionally broad so as not to unduly limit the articles identified by the search.

We searched PubMed (via NLM), EMBASE (via Elsevier), PsycInfo (Ovid), CINAHL (Ovid) and Cochrane (including CENTRAL) from inception through 23 May 2022 (complete search strings are provided in Supporting Information 1). No restrictions were imposed on the language of publication or publication type. We had intended to use Scopus to conduct the forward and backward (citation) search on articles included in full text; however, the authors used SpiderCite instead ([sr-accelerator.com/#/spidercite](http://sr-accelerator.com/#/spidercite)). Forward and backward searches were conducted on 1 June 2022.

## STUDY SCREENING AND SELECTION

### Screening

Search results were screened for eligibility in title-abstract by six authors independently in three pairs (N. M., P. Z., A. R., A. M. S., S. d. J., A. Y.). Records without an abstract were screened based on the title only. Open pilot screening of a convenience sample of 50 records was conducted within each pair before the actual

screening. After title and abstract screening, full texts were retrieved for the remaining articles. Three authors (N. M., A. M. S. and A. R.) independently reviewed the full texts against the inclusion criteria. Full texts were screened in duplicate. Discrepancies during both title-abstract and full-text screening were resolved by consensus or by referring to a third author. We used Screenatron for the screening process and Disputatron to conduct dispute resolution.<sup>33</sup>

### Data charting

Data extraction items were created jointly (N. M., A. Y., A. C., S. d. J.), and an interactive online data extraction form was designed using a custom installation of FormTools (<https://formtools.org/>) by one author (P. Z.). Data extraction was conducted by four authors (N. M., A. R., A. Y., A. C.). Two authors cross-verified 20% (four articles each) of the data extraction. Any disagreements were resolved by discussion with a third author or consensus.

Data extracted included study design, country and setting. Regarding nutrition intervention, data extracted included intervention aim, target audience, intervention content, intervention delivery method and evaluation. Data relating to the co-design process were framework or method of co-design; participants (co-design team), including recruitment and roles/tasks; methods of engagement; and the 'end product' of the co-design process and evaluation (if relevant) of the co-design process. To understand the degree of co-design (i.e., genuine vs. tokenistic), we developed a novel 'ideal co-design' checklist. The checklist assessed six principles of co-design (elevate lived experience, co-governed, equity-centric, diversity, inclusion and capability building) based on the consumer co-author's experience with, and broad consultation about, co-design, with consideration of the literature.<sup>10,12</sup> The checklist also assessed each stage of the co-design process to determine where collaboration (i.e., an equal partnership between lived and professional experience) was reported (co-decide, co-plan, co-design the intervention, co-evaluate, co-disseminate and co-implement). The definitions for each principle and stage are provided in Supporting Information 2.

### Data synthesis

Data were synthesised narratively or quantitatively (frequency counts). We described study locations, types of nutrition interventions and target audiences quantitatively. Data relating to the nutrition intervention and the co-design process are presented in separate tables. For nutrition intervention, we summarised study location, publication time, study name, description and aims, target audience, intervention components and delivery

and evaluation. For the data on the co-design process, we reported on the participants, method of engagement, recruitment, framework or approach and outcomes of the co-design process. We also used the co-design checklist to rank each study on the six elements central to co-design, as well as report on the stages of research that co-design was incorporated. Definitions of co-design stated rationale for co-design, and consumer payments were also summarised.

## RESULTS

### Selection of sources of evidence

Our search identified 8157 records (comprising 441 records from registers, 6601 from the original database

search and 1115 from the forward and backward citation search). A total of 3198 duplicates were removed using Deduplicator software, using the 'cautious' algorithm (<https://sr-accelerator.com/#/deduplicator>), although all records identified by Deduplicator as duplicates were verified by the authors. We screened 4959 records in title-abstract, excluding 4715 and including 244 records for full-text retrieval. All records were retrieved in full text, and 215 were excluded (reasons indicated in Figure 1). We included 19 studies (29 references) in the review (Figure 1).

### Study characteristics

All studies described used either qualitative or mixed-methods design for the co-design process. Studies were

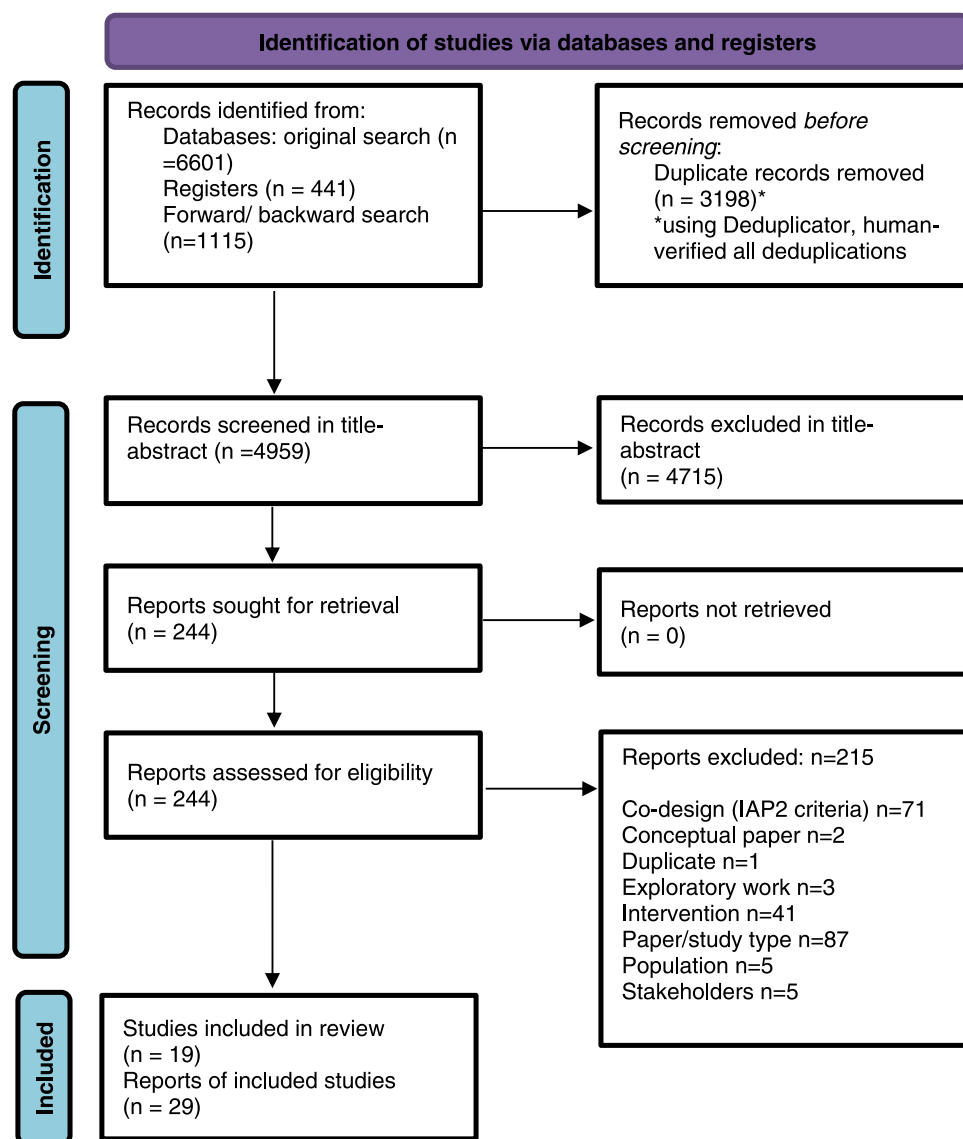


FIGURE 1 PRISMA flowchart<sup>40</sup> for the scoping review process

from a range of countries: the United States,<sup>41–50</sup> Australia,<sup>24,51–55</sup> the United Kingdom and Ireland,<sup>20,56–61</sup> New Zealand,<sup>21,22,62</sup> Canada<sup>63,64</sup> and Iran<sup>23</sup> (Table 2). Although we did not set limits on the publication date for co-designed interventions, 16 of the included studies were published in the past 5 years.<sup>22,24,41,43,44,49,50,52,53,55–57,59,60,63</sup>

## Description of nutrition interventions

### Participants

Target participants of the intervention were adults with or at risk of chronic disease<sup>23,43,44,55,59,63,64</sup>; stroke survivors<sup>24,43</sup>; low-income households<sup>41,42</sup>; carers or persons with additional needs<sup>56</sup> or intellectual disability<sup>60</sup>; women after breast cancer treatment<sup>47,48,54</sup>; adult hospital inpatients<sup>52,53</sup>; and adults of African-American,<sup>46,49,50</sup> African-Caribbean,<sup>20,57,58,61</sup> Māori and Pasifika<sup>21,22,62</sup> or Appalachian descent.<sup>45</sup>

### Types of nutrition interventions

The focus of nutrition intervention was highly varied. Studies focused on improving lifestyle-related risk factors for chronic disease (e.g., type 2 diabetes or stroke),<sup>20–24,43,44,46,49–52,55,57–59,61–64</sup> promoting health and preventing disease after cancer,<sup>47,48,54</sup> improving diet quality or fruit/vegetable intake,<sup>42,45,56</sup> increasing awareness of lifestyle choices and how the body works among adults with intellectual disabilities,<sup>60</sup> or mitigating frailty in recently hospitalised older patients with nutrition support<sup>52</sup> (Table 2).

### Delivery

Nutrition interventions were predominately face-to-face delivery<sup>20,23,41,43,44,46,49,50,52,53,56–58,60,61</sup> or delivered via a web page or mobile app.<sup>21,22,42,47,48,59,62–64</sup> One intervention involved text messages only<sup>54</sup> (Table 2). Not all interventions were at the point of evaluation, having completed only the co-design stage in recent years.<sup>24,52,54,55,59,60</sup> No studies had evaluated the co-designed intervention against a non-co-designed intervention.

### Evaluation

Eight studies had evaluated nutrition intervention,<sup>22,23,41,49,53,56,59,61</sup> with several more indicating that a randomised control trial (RCT) or other evaluation is planned. Evaluation commonly involved acceptability and feasibility,<sup>49,53,56,61</sup> dietary intake,<sup>23,41</sup> biochemical

or anthropometric measures<sup>22,23,41,61</sup> and patient-reported outcome measures.<sup>22,41,56,61</sup>

## The co-design process

### Defining co-design and rationale

Only ten studies<sup>22–24,42,50,52–55,60</sup> provided a definition for co-design (or related research approach), all of which were from different sources. For those studies that provided a rationale for using a co-design approach, the most common reasons were to ensure the intervention was generally appropriate or met the needs of the end users,<sup>42–44,48,49,53,59,63,64</sup> was culturally appropriate<sup>22,41,49</sup> for its target audience, integrated knowledge of the users,<sup>60</sup> ensured end-user priorities were at the forefront<sup>54</sup> or, to be collaborative, shared power or empowered stakeholders.<sup>24,52,55,61,62</sup>

### Participants

As per the inclusion criteria, all studies included consumer representatives (persons with lived or observed experience) as part of the co-design process (Table 3). However, the characteristics of participants were poorly described, whereas the professional experience of other team members (e.g., researchers and healthcare workers) was often included in greater detail.

### Recruitment and method of engagement

Focus groups, workshops, meetings and interviews were the most common methods of engagement for co-design (Table 3), and online methods of engagement were rarely used. Recruitment methods and outcomes of co-design are presented in Table 3. Commonly, recruitment was through research registries or based on previous engagement with research<sup>24,41,50,55,56,61,63</sup> and through community groups or networks.<sup>22,23,45,47,48,52,54,63</sup> Three studies did not describe the recruitment process,<sup>43,44,53</sup> and one study was initiated by persons with lived experience who served as part of the co-design team.<sup>60</sup> Furthermore, consumer payment (honorarium or gift vouchers) was reported only in six of the included studies.<sup>41,42,44,50,52,55</sup>

### Theoretical approaches and frameworks for co-design

There was variability in the theoretical approaches, methods or frameworks taken for co-design (Table 3). The most common approaches cited were integrated knowledge translation,<sup>24,53,63</sup> community-based participatory research or participatory action research<sup>44,48,55</sup>

TABLE 2 Included studies and details of nutrition interventions

Author (year) Other included papers	Country	Study name/description and aim	Target audience	Intervention components and delivery	Evaluation
Ahmed et al. (2020) <sup>41</sup>	United States	Eat fresh to enhance dietary quality and food sovereignty on the Flathead Reservation by improving access to fresh plant-based foods that are affordable, convenient, desirable and sustainable	Low-income households registered for the Food Distribution Program on Indian Reservations	Intervention components: provision of fresh fruit and vegetable box weekly; education targeting food and nutrition knowledge, attitudes, behaviours and skills focused on preparing meals with fresh fruits and vegetables Delivery: face to face	Pre- and post-surveys: food procurement practices and perceptions, dietary quality, anthropometric measures of body weight, body mass index (BMI) and blood pressure, perceptions of health
Atkinson et al. (2009) <sup>42</sup>	United States	Eat smart; be fit to support/extend the goals of the Food Stamp Nutrition Education Program for women and their households; web page content for women to enable healthy households	Limited-income adult women with at least one child enrolled in school	Intervention components: web page content for nutrition and physical activity and content for children and local resources Delivery: web page	Not evaluated
Borek et al. (2018) <sup>56</sup>	United Kingdom	Healthy parent carers programme To target both physical health and mental well-being, focusing on parent carers' outcomes and involving a range of behaviours that can be tailored to parents' needs, preferences and opportunities	Primary carer of a child or young person with additional needs and/or disabilities below 25 years	Intervention components: give-and-take well session included 'eat well' group brainstorming, video, group activity, group discussion, participant and facilitator manuals and a website for parent carers, with additional resources relevant to the programme Delivery: face to face and web page	Feasibility and acceptability, health utility, depression symptoms, well-being scale
Donald et al. (2019) <sup>63,64</sup>	Canada	My kidneys my health To support self-management of chronic kidney disease (CKD) through an e-health tool	Persons, and caregivers of persons, with CKD	Intervention components: food guide/tool (food database with nutrient content) so users can create a personalised CKD-friendly food list, nutrition label and food ingredient list reading and tips for eating out Delivery: e-health tool	Usability testing only; planned feasibility and acceptability study
Driver et al. (2020) <sup>43</sup>	United States	Diabetes Prevention Program Group Lifestyle Balance (DPP-GLB) for stroke To support maintaining weight loss and increase physical activity for people post stroke	Adults, post stroke, and their caregivers	Intervention components: content relating to healthy food choices, calorie and fat intake, physical activity promotion and goal setting Delivery: face-to-face, optional virtual participation, lifestyle coaching	Planned randomised control trial (RCT)



TABLE 2 (Continued)

Author (year) Other included papers	Country	Study name/description and aim	Target audience	Intervention components and delivery	Evaluation
Driver et al. (2017) <sup>44</sup>	United States	DPP-GLB specific to people with TBI To support maintaining weight loss and increase physical activity for people with a TBI	Adults with moderate-severe TBI, BMI 25 or above and their caregivers	Intervention components: content relating to healthy food choices, calorie and fat intake, physical activity promotion and goal setting Delivery: face to face, alternate Digital versatile disc (DVD) option and lifestyle coaching	Planned RCT
Green et al. (2021) <sup>52</sup>	Australia	Being your best To mitigate frailty through themes of physical exercise, cognitive training, social connectedness and nutritional support	Recently hospitalised older persons	Intervention components: modules titled moving well (physical exercise), thinking well (cognitive training), connecting well (social connectedness) and eating well (nutritional support); limited intervention details in the article Delivery: face to face	Not evaluated
Hallsworth et al. (2021) <sup>59</sup>	United Kingdom	VITALISE (intervention to promote lifestyle change in non-alcoholic fatty liver disease [NAFLD]) To increase knowledge and awareness about NAFLD and the risk of NAFLD progression and to highlight the associations with overweight or obesity to increase motivation or intention to make behavioural changes to promote weight loss	Patients with NAFLD (>18 years) and healthcare professionals (HCPs) responsible for their care	Intervention components: eight online modules and lifestyle coaching support Delivery: web page and telephone coaching	Access to content over 12 weeks; requests for lifestyle coaching Future evaluation planned
Katz et al. (2015) <sup>45</sup>	United States	PEACHES (promoting education in Appalachia on cancer and healthy eating styles) and get behind your health to increase colorectal cancer screening and fruit and vegetable intake	Community members of Appalachian counties (aged 50 years or older)	Intervention components: billboards, posters and newspaper media; the posters featured the same community residents and included a short, personal narrative provided by the residents Delivery: health promotion campaign	Not evaluated

(Continues)

TABLE 2 (Continued)

Author (year) Other included papers	Country	Study name/description and aim	Target audience	Intervention components and delivery	Evaluation
Martin et al. (2021) <sup>60</sup>	Ireland	Don't mention the diet! To increase student awareness of how lifestyle choices affect how the human body works	Adults with mild or moderate intellectual disability	Intervention components: general body structure, body functions, caring for our bodies; specific emphasis was placed on self-awareness, self-identity, self-confidence and decision-making Delivery: face to face	Not evaluated Feedback from participants
Moore et al. (2019), <sup>61</sup> Goff et al. (2019), <sup>57</sup> Goff et al. (2021), <sup>20</sup> Goff et al. (2021) <sup>58</sup>	United Kingdom	HEAL-D (Healthy Eating and Active Lifestyles for Diabetes) to improve diabetes self-management for African-Caribbean adults	Black British community (African-Caribbean) adults	Intervention components: group-based culturally tailored education on nutrition and physical activities with behaviour change support and participatory physical activity Delivery: face to face	Acceptability and fidelity, biomedical measures, patient report outcome measures
Singleton et al. (2021) <sup>54</sup>	Australia	Lifestyle-focused text message intervention for women after breast cancer treatment to support the mental and physical health of women after breast cancer treatment	Women after breast cancer treatment	Intervention components: one-way text messages (130 messages in total) Delivery: text messages	Not evaluated
Smith et al. (2016) <sup>47,48</sup>	United States	Mobile cancer prevention app; to promote health and prevent disease among breast cancer survivors	African-American breast cancer survivors	Intervention components: educational materials with prevention guidelines, a diary and reminders, dietary intake tracker, BMI calculator, links to social media, internet educational videos and flags for lapses Delivery: mobile phone app	RCT planned.
Rattray et al. (2021) <sup>53</sup>	Australia	Improving nutrition practices and dietary intake among patients who undergo colorectal surgery	Adult inpatients undergoing an elective colorectal and/or small bowel surgery	Intervention components: 10 strategies at organisational, HCP and patient level Delivery: multi-factorial (systems and face-to-face education)	Intervention reach and delivery, fidelity, HCP awareness, acceptability
Tay et al. (2021) <sup>55</sup>	Australia	Digital dietary intervention prototype To improve nutrition practices and dietary intake among patients who undergo colorectal surgery	Adults at risk of type 2 diabetes	Undefined – only first of the development process Delivery: mHealth	Future evaluation planned

TABLE 2 (Continued)

Author (year) Other included papers	Country	Study name/description and aim	Target audience	Intervention components and delivery	Evaluation
Te Morenga et al. (2018) <sup>22</sup> Verbiest (2019), <sup>62</sup> Ni Mhurehu (2019) <sup>21</sup>	New Zealand	OL@-OR@ mobile health programme for Māori and Pasifika communities in New Zealand to support healthy lifestyle behaviours	Adults in Māori and Pasifika communities	Intervention components: information on healthy eating and physical activity; culturally relevant information; and links to local activities and services, goal setting, lifestyle trackers, regular culturally tailored tips on eating healthily, being more active, reducing stress, improving sleep and managing weight were sent as app notifications (four to five tips per week) Delivery: mobile app	Self-reported adherence to health-related behavioural guidelines at 4 and 12 weeks, self-reported body weight, holistic health and well-being status and user engagement
Wright et al. (2018) <sup>50</sup> Moss (2019), <sup>46</sup> Wright (2020) <sup>49</sup>	United States	Hypertension health education intervention To promote self-care and reduce blood pressure	Older African-American women	Intervention components: blood pressure monitor; educational group sessions with educational materials from various organisations and companies Delivery: face to face	Acceptability and estimated costs to deliver the intervention
Yazdanpanah et al. (2012) <sup>23</sup>	Iran	Community-based participatory diabetes care programme To improve diabetes control and its risk factors among type 2 diabetes patients	Adults aged 30–65 years (all households in the western suburbs of Yasouj)	Intervention components: screening of all households, nutrition education, and physical activity groups Delivery: face to face	Biochemical markers, dietary intake, exercise
Zacharia et al. (2021), <sup>24</sup> English et al. (2021) <sup>51</sup>	Australia	i-Rebound after Stroke 'Eat for Health' Lifestyle interventions to reduce second stroke risk	Stroke survivors	Intervention components: individual diet counselling, behaviour change techniques; optional text message support, optional Facebook support group Delivery: face to face with a text message/social media support	Future evaluation planned

Abbreviation: DVD, digital versatile disc; TBI, total brain injury.

TABLE 3 The co-design process as described in the included studies

Author (year)	Participants and method of engagement	Recruitment	Co-design framework or approach	Outcomes of co-design
Ahmed et al. (2020) <sup>41</sup>	Community Advisory Board is composed of stakeholders who live and work on the Flathead Reservation (tribal elders, educators, enterprise representatives, clinical practitioners and policymakers, including a member of the Tribal Council) Delphi method Structured surveys Focus groups	Community Advisory Board was decided by the research team based on previous experiences in the community as well as a snowballing approach of consultation with experts in the community in the areas of food and nutrition	Delphi method	An intervention that was tailored to meet the specific needs of community residents and the cultural appropriateness of the programme
Atkinson et al. (2009) <sup>42</sup>	Mothers with limited incomes and at least one child enrolled in school; a trained moderator was used Interviews Focus groups Usability testing	Flyers were posted in key locations and distributed by community service providers, including faith-based leaders. Lists of food stamp recipients were obtained from the Maryland Department of Human Resources to recruit persons directly via the telephone	User-centred design	Website developed through a user-centred design process
Borek et al. (2018) <sup>56</sup>	Intervention was designed with 39 parent carers, who would be the consumers of this intervention. Other stakeholders included NHS health trainers, representatives from the local authority and colleagues from the National Network of Parent Carer Forums and the Council for Disabled Children Working group meetings Emails or phone calls	Existing engaged consumers Advertised online on the research group's website and social media of relevant local organisations for parent carers Personal networks of parent carers involved in the working group	Intervention mapping	A group-based intervention to improve health and well-being through engagement with eight achievable behaviours; research plan including interpretation of results and future directions
Donald et al. (2019) <sup>63,64</sup>	Patients with chronic kidney disease (CKD), caregivers, clinicians, researchers, software developers, graphic designers and policymakers were involved in all steps of this study Focus groups Consensus workshop using personas Heuristic usability testing through in-person 60-min interviews	Participants were recruited via email from the Can-SOLVE CKD Network and from among prior focus groups and interviews with participants Purposive sampling, individuals from CKD and general nephrology clinics in Calgary, Alberta, were invited to participate	Integrated knowledge translation Strategy for Patient-Oriented Research patient engagement principles Knowledge-to-action framework Guidance for Reporting Involvement of Patients and the Public)	Used personas to determine broad topic areas and identify features to support chronic kidney disease self-management through an e-health tool Evaluation of the co-design process
Driver et al. (2020) <sup>43</sup>	Advisory Board of 29 stakeholders, including 6 patients and 1 care partner, 2 board-certified physiatrists, 6 rehabilitation therapists, 1 neuropsychologist, 1 exercise specialist, 2 dietitians, 1 health and wellness practitioner, 1 representative from the American Heart Association and 1	Not described	Community-based participatory research	A modified Diabetes Prevention Program Group Lifestyle Balance (DPP-GLB) programme for people after stroke

TABLE 3 (Continued)

Author (year)	Participants and method of engagement	Recruitment	Co-design framework or approach	Outcomes of co-design
Driver et al. (2017) <sup>44</sup>	representative from the University of Pittsburgh Diabetes Prevention Support Center Moderation of group discussion and administrative tasks Meeting with pre-reading	Not described	Participatory action research	A modified DPP-GLB programme for persons with TBI
Green et al. (2021) <sup>52</sup>	Advisory committee with 10 stakeholders representing TBI professionals (physiatry, therapy, nutrition, neuropsychology and research), former TBI patient and caregiver, representative from the University of Pittsburgh Diabetes Prevention Center, key developer of the DPP-GLB and researchers using the DPP-GLB with individuals with mobility impairments Meeting with pre-reading	Healthcare consumer group coordinators were contacted, and an expression of interest to participate was sent for distribution among their members	Boyd's theoretical framework co-design process – engage, plan, explore, develop, decide and change	Programme developed (limited information on the programme available)
Hallsworth et al. (2021) <sup>59</sup>	16 patients with non-alcoholic fatty liver disease to the prototype intervention; needs assessment with 21 HCPs and 12 patients Interviews Workshops	A commercial provider of digital lifestyle behaviour change programmes enrolled to the prototype intervention	Intervention mapping, Theoretical Domains Framework	Needs assessment Form and information content of the intervention
Katz et al. (2015) <sup>45</sup>	Members of cancer community coalitions Focus groups	Cancer community coalitions identified community members to be featured in the promotion	Social cognitive theory underpinned the campaign strategy	Campaign development, including real-world experiences of community members
Martin et al. (2021) <sup>60</sup>	Three adults with mild or moderate intellectual disability and five intellectual disability nurses Not reported	Self-nominated due to frustration with the current situation	Not reported	Education modules were tailored to specific learning needs
Moore et al. (2019) <sup>61</sup>	3 HCPs, 4 community leaders and 20 patients 3 community advocates and 7 patients Community-based workshops	Letters of invitation were sent to people who had participated in previous diabetes research and to eligible participants identified through general practice database searches	Socio-ecological model, behaviour change wheel	1. Behaviour change techniques 2. Development of intervention and supporting materials

(Continues)



TABLE 3 (Continued)

Author (year)	Participants and method of engagement	Recruitment	Co-design framework or approach	Outcomes of co-design
Singleton et al. (2021) <sup>54</sup>	2 women completed active breast cancer treatment (consumers and citizen collaborators) and 4 health professionals and researchers Workshop	From a local volunteer association	Psychological theory to underpin messages	Development of text message programme and content; evaluation of content
Smith et al. (2016) <sup>47,48</sup>	12 members of SISTAAH Talk (Women of Colour Breast Cancer Support Group), treated for >1 year for stages I–IIIc breast cancer, aged 75 years or younger Discussions Demonstrations (cooking) Focus groups Interviews	Identified by leaders of the support group as good role models to participate in developing mobile cancer prevention app	Community-based participatory research	Content for mobile app
Rattray et al. (2021) <sup>53</sup>	Nutrition Reference Committee members included medical staff (surgeons), dietitians, nurses, food service staff and patient representatives (number not reported)	Not described	Integrated knowledge translation and knowledge to action framework	Ten strategies for intervention, research plan
Tay et al. (2021) <sup>55</sup>	End users (pre-diabetes or risk of type 2 diabetes) or professional experts (2 years of diabetes-related work experience) Online workshops	Convenience and purposeful sampling were used. Participants from the Delphi study were invited via email	Delphi method Participatory action research Persuasive design	Desired app features Evaluation of prototypes
Te Morenga et al. (2018) <sup>22</sup>	The OL@-OR@ project team: European nutrition professor, a Māori nutrition researcher, Pasifika public health researcher and representatives of key Māori and Pasifika community health Meetings Focus groups with end users were organised and facilitated by community coordinators	Via community organisations	Adapted participatory co-design cycle described by Bratteteig et al. <sup>65</sup> Theoretical Domains Framework to select Behaviour Change Techniques and incorporated kaupapa Māori principles (Tikanga) into engagement	Development of an app and web page
Wright et al. (2018) <sup>50</sup>	49 community-dwelling African-American adults aged 60 years and older (mostly women) Focus groups Interviews	Established research participant registry maintained by the principal investigator from previous research conducted in the community	Intervention design based on the information-motivation-behavioural model	Self-management of hypertension intervention for women

TABLE 3 (Continued)

Author (year)	Participants and method of engagement	Recruitment	Co-design framework or approach	Outcomes of co-design
Yazdanpanah et al. (2012) <sup>23</sup>	A 15-member group consisted of 4 academics, 3 local leaders, 5 community members and 3 local healthcare providers Community meeting Focus groups Interviews	Selected by a steering committee Participatory process involving open meetings held in public places (most often a local health centre) Anyone who attends the meeting is invited to join a working committee	Planned approach to community health	Set priorities Guided all aspects of the study and the intervention Proposal for baseline health survey and intervention programme
Zacharia et al. (2021) <sup>24</sup>	A series of stakeholder workshops were held with four stroke survivors, two carers and six specialist disability dietitians. A second series of workshops were held with six stroke survivors and carers and six dietitians to refine and adapt the intervention prototype Workshops	Recruited from a variety of sources: from the initial ENABLE trial co-design process ( $n = 4$ ), utilising professional networks ( $n = 6$ ) and through word of mouth ( $n = 2$ )	Integrated knowledge translation	Essential elements of the programme Defined research questions Prototype development Prototype adaptations

Abbreviation: TBI, total brain injury.

and intervention mapping.<sup>56,59</sup> Only two studies cited the use of specific co-design frameworks.<sup>22,52</sup> Several studies used the Theoretical Domains Framework,<sup>21,55,56,59,61</sup> COM-B or Behaviour Change Wheel<sup>20,24,58,61</sup> to apply behaviour change techniques to the intervention based on the analyses taken from discussions with consumers. Only one study<sup>64</sup> reported consumer engagement in line with the GRIPP2-SF.

### ‘Ideal co-design’: principles and stages

Four studies<sup>22,52,56,63</sup> reported evidence of including five or six principles of ‘ideal co-design’, whereas further five studies<sup>23,41,43–55</sup> included three or four of the co-design principles, ‘sometimes’ or ‘all of the time’ (Table 3). The most common co-design principles reported were ‘elevate lived experience’, ‘equity-centric’ and ‘inclusion’, whereas ‘diversity’, ‘co-governed’ and ‘builds capability’ were the least likely principles to be included or reported (Table 3). Six studies either failed to report against the six principles or included only one principle<sup>45,47,53,54,59,61</sup> (Table 3).

Equal partnership between consumers and researchers was most reported within the stage of ‘co-designing the intervention’ (Table 3). However, many studies also incorporated co-decision-making, co-planning and co-dissemination (Table 3). Two studies reported an equal partnership across all six stages<sup>56,63</sup> (Tables 3 and 4).

### Consumer as a co-author in the present review

A summary of the contributions of the consumer co-author and the reflections on the benefits and challenges from the consumer and researcher perspective is provided in Box 1. Reporting of consumer involvement in accordance with GRIPP2-SF is provided in Supporting Information 3.

## DISCUSSION

This scoping review set out to synthesise the current use and extent of consumer co-design in nutrition interventions. We identified 19 studies (29 references) meeting the inclusion criteria. Although co-design is not a new concept, most studies included were from the past 5 years, indicating a shift towards the adoption of consumer-centred design in more recent years. However, very few studies included consumers across the spectrum of research stages, and their inclusion was often limited to co-designing the intervention.

What is not entirely clear from this review is whether the execution or reporting of co-design was poor. However, unclear reporting of participatory research methodology is an issue evident in prior research.<sup>39,66,67</sup>

TABLE 4 Checklist co-designed with consumer representative that captures key elements of co-design

Author (year)	Elevate lived experience	Co-governed	Equity-centric	Diversity	Inclusion	Builds capability	Co-design stages of research <sup>a</sup>
Ahmed et al. (2020) <sup>41</sup>	b	b	NR	b	c	NR	Co-decide <sup>b</sup> Co-plan <sup>c</sup> Co-design intervention <sup>c</sup> Co-implement <sup>b</sup>
Atkinson et al. (2009) <sup>42</sup>	b	NR	b	NR	d	NR	Co-decide <sup>b</sup> Co-plan <sup>d</sup> Co-design intervention <sup>c</sup>
Borek et al. (2018) <sup>56</sup>	c	c	c	b	b	c	Co-decide <sup>c</sup> Co-plan <sup>c</sup> Co-design intervention <sup>c</sup> Co-evaluate <sup>c</sup> Co-disseminate <sup>c</sup> Co-implement <sup>c</sup>
Donald et al. (2019) <sup>63,64</sup>	c	c	c	b	c	c	Co-decide <sup>c</sup> Co-plan <sup>c</sup> Co-design intervention <sup>c</sup> Co-evaluate <sup>c</sup> Co-disseminate <sup>c</sup> Co-implement <sup>c</sup>
Driver et al. (2020) <sup>43</sup>	NR	c	b	c	NR	NR	Co-decide <sup>c</sup> Co-plan <sup>d</sup> Co-design intervention <sup>c</sup>
Driver et al. (2017) <sup>44</sup>	d	b	b	NR	NR	b	Co-decide <sup>b</sup> Co-plan <sup>d</sup> Co-design intervention <sup>c</sup>
Green et al. (2021) <sup>52</sup>	c	NR	c	c	c	c	Co-decide <sup>c</sup> Co-plan <sup>b</sup> Co-design intervention <sup>c</sup>
Hallsworth et al. (2021) <sup>59</sup>	b	c	d	NR	d	c	Co-decide <sup>b</sup> Co-plan <sup>d</sup> Co-design intervention <sup>c</sup> Co-evaluate <sup>d</sup> Co-implement <sup>e</sup>
Katz et al. (2015) <sup>45</sup>	NR	NR	NR	NR	NR	NR	Co-decide <sup>c</sup> Co-plan <sup>b</sup> Co-design intervention <sup>e</sup> Co-evaluate <sup>c</sup> Co-disseminate <sup>c</sup> Co-implement <sup>d</sup>
Martin et al. (2021) <sup>60</sup>	NR	NR	b	NR	NR	b	Co-decide <sup>c</sup> Co-design intervention <sup>c</sup> Co-evaluate <sup>e</sup> Co-disseminate <sup>c</sup>
Moore et al. (2019) <sup>61</sup>	b	d	e	e	d	e	Co-decide <sup>d</sup> Co-plan <sup>e</sup> Co-design intervention <sup>b</sup> Co-evaluate <sup>d</sup> Co-disseminate <sup>e</sup>
Singleton et al. (2021) <sup>54</sup>	b	d	e	e	e	e	Co-decide <sup>c</sup> Co-plan <sup>c</sup> Co-design intervention <sup>c</sup> Co-disseminate <sup>c</sup>
Smith et al. (2016) <sup>47,48</sup>	NR	NR	NR	NR	b	NR	Co-design intervention <sup>b</sup> Co-evaluate <sup>b</sup> Co-disseminate <sup>c</sup> Co-implement <sup>c</sup>

TABLE 4 (Continued)

Author (year)	Elevate lived experience	Co-governed	Equity-centric	Diversity	Inclusion	Builds capability	Co-design stages of research <sup>a</sup>
Rattray et al. (2021) <sup>53</sup>	NR	NR	NR	NR	NR	NR	Co-decide <sup>e</sup> Co-plan <sup>e</sup> Co-design intervention <sup>d</sup> Co-evaluate <sup>d</sup> Co-disseminate <sup>d</sup> Co-implement <sup>d</sup>
Tay et al. (2021) <sup>55</sup>	b	e	c	b	b	NR	Co-decide <sup>b</sup> Co-plan <sup>e</sup> Co-design intervention <sup>c</sup> Co-evaluate <sup>e</sup> Co-disseminate <sup>e</sup>
Te Morenga et al. (2018) <sup>22</sup>	c	c	c	NR	c	c	Co-decide <sup>c</sup> Co-plan <sup>c</sup> Co-design intervention <sup>c</sup> Co-evaluate <sup>c</sup> Co-disseminate <sup>c</sup>
Wright et al. (2018) <sup>50</sup>	NR	e	c	e	c	e	Co-decide <sup>e</sup> Co-plan <sup>e</sup> Co-design intervention <sup>b</sup> Co-evaluate <sup>e</sup> Co-disseminate <sup>e</sup>
Yazdanpanah et al. (2012) <sup>23</sup>	NR	c	b	NR	c	c	Co-decide <sup>c</sup> Co-plan <sup>c</sup> Co-design intervention <sup>b</sup> Co-evaluate <sup>c</sup> Co-disseminate <sup>c</sup> Co-implement <sup>b</sup>
Zacharia (2012) <sup>24</sup>	NR	NR	b	e	e	NR	Co-plan <sup>b</sup> Co-design intervention <sup>c</sup> Co-evaluate <sup>e</sup> Co-disseminate <sup>c</sup>

Note: Rankings were determined by two authors and cross-checked by a third author.

Abbreviation: NR, not reported.

<sup>a</sup>Item not included if the study did not report.

<sup>b</sup>Sometimes.

<sup>c</sup>Always.

<sup>d</sup>Rarely.

<sup>e</sup>Not at all.

Although there are no reporting guidelines for co-design, the GRIPP2 guidelines<sup>37</sup> provide guidance on reporting patient and public involvement in research. These guidelines were cited in only one of the included papers in this review. The GRIPP2 guidelines<sup>37</sup> aim to cover consumer involvement in all its forms, and although they prompt authors to report on the level and nature of involvement, direction about the terminology and definitions are lacking. As also suggested by other authors, adaption of existing reporting guidelines for co-design may be warranted.<sup>39,68</sup> We suggest that the use of a well-known consumer engagement spectrum such as IAP2<sup>15</sup> in reporting may provide clarity regarding the level and nature of engagement and allow co-design (or collaboration) to be more specifically named as the engagement method. The reporting issue was also

evident in data extraction where studies published one or more companion articles that described the co-design process and outcomes of the intervention separately. The authors found that articles describing both the co-design process and intervention description/outcomes were often lacking detail on one part of the study. This may be due to a lack of co-design reporting guidelines or strict word limits imposed by some journals, hindering the ability to fully describe the engagement principles of co-design at each stage of the process. Many of the studies published only the co-design process with limited details on the intervention. However, these studies often indicated that further research was planned, including a full description and evaluation of the intervention.

'Ideal co-design' includes an equal partnership at all research stages that embraces the principles of elevating

## BOX 1 Consumer contribution to the review process

### Role and influence in the review:

- Contributed to the definition of co-design used: reviewed existing definitions in the literature, nominated key aspects for inclusion in definition (i.e., power sharing, partnership between lived and professional experience) and developed final definition used in review (based on previous consultation about co-design with >100 consumers, health professionals and researchers)
- Suggested additional search terms based on previous consultation about co-design (e.g., user-centred design)
- Contributed to the refinement of protocol: changed inclusion criteria (based on lived experience with transitions to adult services between ages 16 and 18 years) and reviewed protocol before publication
- Resolved conflicts during full-text review: provided judgement related to inclusion/exclusion based on the co-design criteria
- Led the development of an 'ideal co-design checklist' (based on lived experience and previous consultation about co-design), with review by co-authors N. M. and A. Y.
- Completed data extraction on half of the included papers using the checklist (performed in partnership with A. Y.)
- Contributed key points for inclusion within the discussion: need for researchers to *listen* to the lived experience when undertaking co-design (rather than prioritising the research evidence), misreporting of 'consultation' or 'involvement' as co-design
- Drafted paragraph in the discussion related to co-design principles and process
- Reviewed final manuscript before submission

### Team reflections on consumer involvement in the review process: Benefits:

- Ensured our definition and inclusion criteria were true to the key principles of co-design
- Initiated the co-design of a new tool to assess the degree to which co-design is reported, based on extensive experience working alongside other persons with lived experience across multiple projects
- Provided an alternative (lived experience) perspective on engaging throughout the co-design process, data extraction, and contributing significantly to the methods and discussion
- Increased confidence in full-text review based on consumer interpretation of the reported co-design process
- Continued learning for research team members about what is important in co-design through discussions at team meetings, the co-design checklist and interpretation of study findings

### Challenges:

- Time pressures in the speed of the review presented limited opportunities for building capability. This was mitigated by regular meetings and engagement between the research team; however, if given additional time, the benefits could have been maximised.

- Online engagement: A. C. completed the entirety of the review through online engagement, which limited informal and casual discussion about papers during data extraction. Although online engagement provided inclusive participation benefits, completing initial data extraction in the same room as other researchers would boost consumer confidence in competency and accuracy and shared learning.
- Issues related to access to different file sharing and communication channels.
- Changes to role/expectations mid-way through review to include data extraction.

lived experience, co-governance, equity-centric, diversity, inclusion and capability building.<sup>10,12</sup> Regardless of reporting, co-design was incorporated to varying degrees across all research stages and principles, with challenges presented by lack of consistent reporting of a co-design definition or approach, consumer involvement and adherence to principles. Indeed, fewer than half of the studies included for this scoping review defined co-design (or similar method used), and there was no unifying definition across any of the studies. McGill et al. in their scoping review of 71 co-produced interventions for the prevention of chronic disease highlighted the interchangeable use of co-words such as 'co-design', 'co-create' and 'co-develop' when describing the involvement of end users or intermediaries.<sup>69</sup> In this review we chose to include studies that demonstrated a partnership with consumers (as aligned with the final two levels on the IAP2 Public Participation Spectrum<sup>15</sup>) to provide consistency in our definition. When considering this approach alongside the three main arguments of public involvement in research as outlined in Greenhalgh et al., genuine co-design should acknowledge that consumers have the right to input into researching their condition, increase its relevance to consumers and dissemination beyond academic audiences and form alliances with consumers (knowledge co-constructed with researchers and the public) to increase accountability and transparency.<sup>12</sup>

Lack of consistency in terms and definitions used for co-design suggests there may be limited awareness of principles to incorporate or how to co-design from beginning to end of the research process. It was also evident that co-design theoretical models or frameworks varied greatly, and there appear to be limited approaches to specifically guide co-design processes. This has implications for future research. Although several proposed co-design models and frameworks exist,<sup>70-72</sup> these tend to focus on the process (steps involved) rather than the measures or determinants of genuine co-design. They also fail to incorporate co-design across the research spectrum. For example, in



this scoping review we found that research direction and methods were rarely co-designed, demonstrating lack of engagement with consumers from research inception. Planning research and priority setting with consumers is an important strategy to reduce research waste.<sup>73</sup> In this review we found that an equal partnership between professional and lived experience was most commonly reported in the co-design of the intervention. Other co-design research stages (i.e., co-deciding, co-planning, co-implementation and co-evaluation) were underreported and rarely included consumers in equal partnership. However, even with this occurring, the evidence base or researcher perspective was often given greater emphasis than lived experience perspectives. Examples of this were observed where consumers suggested an intervention idea that was then not followed through to design due to the emphasis on evidence-based interventions. Instances where there was a conflict between lived experience perspectives and existing literature created the opportunity for researchers to 'elevate lived experience'. Rarely did the research team incorporate lived experience expertise in the final product, even when there was not a competing existing evidence base for the intervention.

As observed with the stage of research planning/direction setting, co-design within the evaluation of the intervention process was notably missing. Only two of the studies in this review included sufficient details of co-designed evaluation measures.<sup>22,23</sup> In both studies, consumer co-designers were included in decisions about evaluation measures. In their systematic review of frameworks supporting patient and public involvement in research, Greenhalgh et al.<sup>12</sup> proposed that study-focused frameworks enable consumer involvement to be woven into every stage of research, including monitoring and evaluation. In the present scoping review, it was our consumer author (A. C.) who proposed and co-developed the checklist, which enabled us to describe 'ideal' co-design across all research stages.

The lack of 'capability building' between professional and lived experience presented missed opportunities for different perspectives to be challenged and shared learning (un-learn, co-learn, re-learn). At times, it was not clear whether the input from the consumers with lived experience was integrated into the co-design and occasions where input from people with lived experience was asked for but not incorporated. Consumers had to repeat the same requests in consultations, only to receive an intervention prototype that did not meet their needs or reflect the lived experience expertise provided. Incorporating 'capability building' could enable lived experience to be elevated throughout the co-design process rather than 'tokenistic' engagement. The need for guidance around capability building for the entire co-design team has been identified as a barrier to authentic co-design in previous research.<sup>74</sup> A focus

on capability building using emerging models<sup>74,75</sup> would support stronger relationships between researchers and consumers.

An additional key consideration in consumer co-design is adequate compensation for their contributions. Inadequate resources to remunerate consumers for their time and expenses incurred, while expecting voluntary contributions, impact on recruitment of co-design participants<sup>76</sup> and compromise the principle of equal partnership.<sup>60</sup> Only a third of studies included in this review reported compensation for consumer involvement, questioning the genuine commitment to valuing the contribution of consumers to the co-design process. Reimbursement of expenses and remuneration for time are important; however, it may be that this needs to be individualised to each consumer and context.<sup>77</sup> In developing the approach to consumer co-design, asking participants their preferences for reimbursement and acknowledgement may help facilitate engagement<sup>77</sup> and, therefore, enhance the outcomes of co-design.

Interestingly, the 19 studies included in this scoping review did not appear in a recent integrative review<sup>39</sup> that aimed to describe co-design in nutrition research. The authors of the integrative review included 22 studies that met collegiate, collaborative or consultative levels of participation<sup>78</sup> and found that only 3 met the collegiate level.<sup>39</sup> More commonly, included studies were used to assess background knowledge and user needs to inform an intervention, whereas we excluded studies that appeared to 'consult' participants or explore general barriers/enablers and perceptions.<sup>39</sup> To be considered for this scoping review, we applied strict criteria of consumer participation that required researchers to 'Collaborate' with or 'Empower' consumers in line with the IAP2 spectrum.<sup>15</sup> In addition, we note that many of the studies included in this scoping review were published in 2021, which would have meant they were unavailable during screening for the 2021 integrative review.

This study was not without its limitations. Through excluding co-design studies that aimed to improve food access by addressing food security, we limited the breadth of studies reporting co-design with nutrition interventions. However, the authors felt that this was a topic that warranted closer examination under a separate review and recommend this for future scoping reviews. Further, it is possible that many co-design papers were excluded as they did not meet the IAP2 criteria. Although not a major focus of this review, we may have overlooked learnings that encompassed a transition from no consumer involvement to 'partial-but-not-quite-there' consumer involvement. The 'ideal co-design' checklist was developed for this study to subjectively assess the co-design as it was reported in the included papers. Given the poor reporting of co-design, it is likely that some co-design principles were not reported and therefore not assessed. This novel tool may be useful to guide the planning and reporting of future co-design studies but

requires further use, refinement and potentially validation. The exclusion of grey literature where co-design work may be more commonly published is another limitation of this review.

The strengths of this review are the broad and complementary expertise of the reviewers and the systematic methodology applied to the review. Authors' expertise ranged from experienced content experts (dietitians, behaviour change experts), systematic review methodologists and, importantly, a consumer as an integral and equal part of the team. This unique combination allowed skilled refining of search terms, the inclusion of a definition and checklist aligned with a genuine co-design approach and application of automated tools to expedite the process. This review adapted an accelerated (2weekSR) process<sup>33</sup> and used multiple communication channels (Microsoft Teams, Slack and email) and real-time queries ensuring decisions were able to be shared, addressed and documented for clarity of processes. Despite more rapid reviews of this type emerging, the novelty of this approach is a study strength. Furthermore, it continues to contribute to the body of knowledge on time taken and processes and tools required in the rapid scoping review, extending the potential to realise considerable time and efficiency savings. Additional strengths included the use of five scientific databases, with studies independently screened by three pairs of two reviewers, and data were extracted by four co-authors, with cross-verification processes applied. We also did not impose restrictions on time periods for publication or language.

This review demonstrates that although there is an appetite for and obvious benefits of consumer co-design in nutrition interventions, it is not performed systematically or rigorously. Improvements in understanding the definitions of and methods to enable, enhance and honour true and authentic consumer co-design are much needed, as is reporting of processes undertaken.

## AUTHOR CONTRIBUTIONS

Nina J. L. Meloncelli, Susan de Jersey and Adrienne Young conceived the study; Anna Mae Scott developed the methodology with input from all authors; screening was undertaken by Nina J. L. Meloncelli, Anna Mae Scott, Alita Rushton, Susan de Jersey, Adrienne Young and Pavel Zhelnov; data extraction and interpretation were performed by Nina J. L. Meloncelli, Alita Rushton, Adrienne Young and Anja Christoffersen; verification was performed by Pavel Zhelnov, Alita Rushton and Nina J. L. Meloncelli. All authors contributed to drafting the manuscript, reviewing or editing. All authors have read and agreed to the submitted version of the manuscript.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

## TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with PRISMA-ScR guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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