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# JUNE OF HUMAN NUTRITION AND DIELECTORY

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The Association of UK Dietitians

# Journal of Human Nutrition and Dietetics

The Official Journal of the British Dietetic Association

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NUTRITIONAL SUPPORT AND ASSESSMENT

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# Self-completed online dietary recalls as an alternative method of dietary assessment for dietetic outpatient appointments: A feasibility study

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#### Abstract

Background: Integrating digital dietary assessment within dietetic care could save time and reduce costs, at the same time as increasing patient engagement. The present study explores the feasibility of implementing a web-based dietary assessment tool, myfood24 (https://www.myfood24.org), into routine healthcare. Methods: This mixed methods feasibility study recruited dietitians and patients from a National Health Service (NHS) hospital outpatient setting. Patients completed and shared three online 24-h dietary recalls in advance, which were used as a dietary assessment by dietitians. Recruitment data were collected and questionnaires on technology, usability, and acceptability were completed. Patient interviews and focus groups with dietitians were conducted.

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Results: Eleven dietitians working in allergy, bariatrics, diabetes, oncology, general, renal, infectious diseases, and coeliac services took part with 39 patients. Recruitment rates were highest in bariatrics and lowest in renal and oncology.

Compared to other studies, completion rates were good, with 29 (74.4%) completing three recalls despite lower technology readiness and software usability scores than in similar studies. Illness and difficulty with technology were reasons for non-completion. Opportunity to receive nutritional feedback from the tool and share this with a dietitian motivated patients to complete the record accurately. Consultation times were shortened in approximately onethird of appointments and a higher proportion of time was spent on nutritional education compared to usual practice. However, mean preparation time increased by 13 min per appointment because dietitians found nutritional analysis reports difficult to interpret.

Conclusions: It is feasible to introduce a digital dietary assessment tool into NHS dietetic practice. However, further development is needed to ensure that the tool is suitable for healthcare.

#### **KEYWORDS**

technology, dietary assessment, dietetics, digital health

# **Key points**

- This is likely to be the first study in the UK investigating the use of digital dietary assessment in clinical dietetic practice.
- · Seven different clinical specialities were included. Recruitment rates were highest in bariatrics and lowest in oncology and renal where ill health was given as a main reason for non-participation.

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Non-completers had low technology readiness scores, which may suggest this tool could be used to identify individuals who may need more technological support.
Dietitians reported that clinic preparation time took longer than usual care, but time was saved in one-third of consultations and more time was available for patient education.
The intervention was moderately acceptable to patients and dietitians, although tailoring the software to clinical care and the availability of an app would likely improve this further.

# INTRODUCTION

Dietary assessment is an essential element of the nutrition care process in dietetic clinical practice.<sup>1</sup> Established assessment methods such as 24-h dietary recalls and paper food diaries require time and skills for both healthcare professionals (HCP) and patients and yet may be inaccurate because of under-reporting, misinterpretation, or daily variations in intake.<sup>2</sup> In epidemiological research, digital dietary assessment tools have been shown to improve completion rates, increase the accuracy of estimated nutritional intakes,<sup>3–5</sup> and reduce costs.<sup>6–8</sup> The number of tools available is growing and best practice guidance on their development has become necessary.<sup>9</sup> They have become more popular with the general public<sup>10-12</sup> and have begun to be used in healthcare.<sup>13</sup> They have the potential to benefit practice by providing valid estimates of nutritional intake in advance of a consultation,<sup>14,15</sup> thereby saving clinician time.<sup>13,16–18</sup> They enable remote appointments and monitoring, reducing hospital visits and associated treatment costs.<sup>12,13</sup> They also provide instant feedback to individuals on their dietary intake, thus improving self-management skills, treatment satisfaction, and quality of life, which are associated with improved clinical outcomes.<sup>13,16,17</sup>

Despite evidence of these benefits in dietetic care,<sup>12</sup> digital tools are yet to become integrated into practice<sup>18,19</sup> and change is slow, leading to warnings that the UK dietetic profession could be left behind in the move to digital technologies.<sup>20</sup> Future Dietitian 2025 calls for support for UK dietitians to address this by expanding the evidence base.<sup>21</sup> To the best of our knowledge, there are no UK studies exploring the use of digital dietary assessment in the NHS and therefore studies are urgently needed.

The present study aims to explore the feasibility of adopting a digital dietary assessment tool, myfood24 (https://www.myfood24.org), into routine dietetic practice. The study seeks to investigate its use with a diverse dietetic outpatient clinical population and consider recruitment and retention, intervention delivery, and patient and practitioner views about usability and acceptability in this setting, aiming to inform further research and development in this area.

# **METHODS**

# Digital dietary assessment tool

The assessment tool myfood24 was chosen for use in the present study. A consortium of UK academics, including nutritional epidemiologists and dietitians, funded by the Medical Research Council, iteratively developed<sup>8</sup> and validated<sup>22,23</sup> the tool. The design characteristics of myfood24 in comparison to other tools are well documented.<sup>9,24</sup> Characteristics of potential clinical benefits include a food database that uniquely provides micronutrient values for 40,000 foods and automatic data sharing between the user and provider.<sup>12,19</sup> One of the investigators (CG) had previous knowledge of the tool and has collaborated with the developers previously. Its main shortcomings at the time of the present study were that it was not yet optimised for a healthcare setting and access was via a website.

The tool is used by patients and dietitians. Patients complete a 24-h food record by searching for their food items from a database of generic and branded foods and various portion size guides can assist with portion estimation. Once the full day is completed and submitted, the website provides the patient with a report of the nutritional analysis of their dietary intake in the form of charts and tables. In addition to data on macronutrients, other nutrients of interest can be selected. Dietitians log on to myfood24 to view their list of patients and select an individual. They then have access to different reports relating to that patient's submitted food records. This includes similar feedback reports to the one that the patient receives, which they can use as an educational tool in consultations to discuss findings and trends. Additionally, they can access detailed nutritional analysis of every food item consumed for around 100 nutrients. This takes the form of spreadsheets, which the dietitians can manipulate to reduce the volume of data and tailor to each individual patient.

# Setting

This feasibility study took place in the Dietetic Department of a large teaching hospital in the United Kingdom. Two of the investigators (CG and CT) were employed in this setting as registered dietitians; however, they had no prior relationship or clinical responsibility for the patients recruited for the study.

# Participants

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Eligible participants were dietitians providing outpatient care and their patients. Patients were eligible if they were aged over 18 years, could read and understand English, had an email address and access to the Internet, and were due to attend a dietetic out-patient appointment (OPA) within the study period.

# Recruitment

CG and CT promoted the study to dietitians through team meetings, and eligible dietitians were invited to take part by letter.

Patients were initially screened from dietetic outpatient referrals and clinic lists and eligible patients were contacted and invited to take part. If they expressed

Initial screened and invited patients = 244Not eligible = 32(13%)18 no internet 2 non-English speaking 12 no appointment with dietitian within research timeframe Final eligibility checked and Declined invitation =173 (82%) invited =212 Reasons. Not known = 59Not interested = 56Lack of time = 36Too unwell = 11Failed to attend consent appointment = 8No interest technology= 3Consented = 39(18%)Completed no food recalls =7 **Completed**  $\geq$  **one food recall** =32 (18%)(82%) Did not attend appointment = 2Attended appointment = 29(74%)Attended appointment = 5(of which were interviewed n=13) (of which were interviewed =2)

interest and their OPA was within the study period they were then contacted to make further eligibility checks to make sure they had online access (Figure 1). CG and CT contacted potential participants to answer questions and book consent appointments. The aim was to recruit a diverse population, representative of the clinic population.

# Intervention

At the consent appointment, patients received brief training of the myfood24 system from CG or CT and supporting information was provided. Patient participants were asked to record their dietary intake as accurately as possible using myfood24 for at least 3 days, including week and weekend days to represent their usual food intake, as well as to submit these at least 1 week before their appointment. They were encouraged to view their reports prior to their OPA to generate questions for the dietitian. Dietitians were given brief training and information on how to use the website. They were asked to review the nutritional data of participants prior to their appointments, and to use this in place of their usual dietary assessment method. Otherwise, consultations took place as usual.

# **Data collection**

A screening and recruitment log was kept throughout. Dietitians and patient participants attended a consent appointment where, following consent, demographic and technology use data were collected. Patients also self-completed additional questionnaires. Two validated questionnaires were chosen: (1) The Technology Readiness Index (TRI),<sup>25</sup> which assesses people's readiness to use new technologies in their lives and (2) The Patient Activation Measure (PAM<sup>®</sup>),<sup>26</sup> which measures people's knowledge, skills and confidence in managing their health. These were chosen to provide additional descriptive data about the study population.

At the end of the appointment, patients were provided with the remainder of the study questionnaires, along with instructions on when to complete these and stamped addressed return envelopes. These included a system usability scale (SUS), a validated usability questionnaire assessing ease of use of the website,<sup>27–29</sup> which was completed after doing the three online food recalls, and a bespoke acceptability questionnaire based on a theoretical framework of acceptability,<sup>30</sup> which was completed after their dietetic appointment (see Supporting information, Doc. S1). Both were returned by post or email.

Dietitians completed a questionnaire at the end of each consultation, which sought to compare the consultation with usual care including its duration and content. At the end of the study, they completed an adaption of the patient acceptability questionnaire (see Supporting information, Doc. S1).<sup>30</sup> Both were returned via the hospital's internal post system.

All participating dietitians were invited to take part in focus groups to explore their views following the completion of all their patient consultations. Topics discussed included views on using the website to review patient data, experiences of using the tool in consultations, and ideas for further development of the tool. Three focus groups took place each lasting between one and two hours. They were audio-recorded with consent.

Patient participants were invited to take part in a semi-structured telephone interview at a time of their choice, aiming to explore their experience and views about using the tool. Patients were selected for interview using purposive sampling across a range of relevant characteristics, including age, gender, clinical condition, ethnicity, socio-economic status, and TRI score, also ensuring the inclusion of patients who failed to complete any recalls (non-completers). Because of time constraints, recruitment ended before it was possible to confirm that data saturation was reached. Interviews were conducted by CG and covered topics including views on accessing and using the website, ease of understanding the reports, experience of the consultation, and suggestions for further development of the tool. Interviews lasted approximately 30 min and were audiorecorded with consent.

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This was a pragmatic applied piece of health service research and focus group, and interview questions were developed to explore salient issues relating to the application of the tool. Topic guides were developed and used as aide memoires with opportunity for wider discussion around topics of interest to the dietitians and patient participants. The topic guides used for the focus groups (see Supporting information, Doc. S2) and interviews (see Supporting information, Doc. S3) are available.

# Data analysis: statistical and qualitative analysis

Descriptive statistics were calculated as the mean  $\pm$  SD or median and interquartile ranges (IQR) for continuous data and frequency and percentages for categorical data. Further analysis of demographics and technology readiness examined variables that contributed to recruitment. Comparisons were made using a chi-squared test for categorical data and an independent *t* test for continuous data. For all inferential statistics, p < 0.05 (two-sided) was considered statistically significant.

Interviews and focus groups recordings were transcribed and anonymised. Coding frames were developed based on focus group and interview topic guides (see Supporting information, Docs S2 and S3). Three interview (20%) and one focus group transcript were read and coded independently by CG and LC to check consistency to refine the coding frame. Discrepancies were resolved through discussion before CG coded the remaining transcripts. Codes were grouped into themes relating to the research aims.

# RESULTS

# **Characteristics of participants**

Eleven dietitians, from the eight clinical areas shown in Table 1, consented to the study. Their characteristics are described in Table 2. Agenda for Change (AfC) banding ranged from 5 to 7 and their years of experience working as a dietitian ranged from 1.25 to 25 years (median 4 years).

Figure 1 shows the flow of patient recruitment through the study. Thirty-nine patients (21%) volunteered to participate, and their details are provided in Table 1. They ranged in age from 18 to 84 years, 56.4% were female, 92.3% were white, and 46% were of low socio-economic status (based on index of multiple deprivation). Their demographic characteristics were compared with the characteristics of those who declined to participate. No statistically significant differences were found. Recruitment rates were highest in bariatrics and

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TABLE 1 Characteristics of patients who consented and declined

	Consented, n = 39	Declined, n = 173	
Patient characteristic	n (%)	n (%)	p value*
Age (years), range, mean (SD)	18–84 47.9 (17.8)	18–89 52.1 (18.7)	0.29
<25	3 (8)	14 (8)	
25-65	30 (77)	108 (62)	
>65	6 (15)	51 (30)	
Female	22 (56.4)	97 (56.1)	0.97
Ethnicity			0.16
White	36 (92.3)	137 (79.2)	
Asian	1 (2.6)	18 (10.4)	
Black	1 (2.6)	3 (1.7)	
Other	1 (2.6)	7 (4.0)	
Unknown	0 (0)	8 (4.6)	
Socio-economic status (IMD), mean	4.87	4.3	0.31
Low (1–3)	18 (46)	90 (52)	
Medium (4–7)	12 (31)	46 (27)	
High (8-10)	9 (23)	37 (21)	
Clinical area			NA
General outpatients	15 (38.5)	63 (36.4)	
Coeliac	7 (17.9)	35 (20.2)	
Renal	2 (5.1)	21 (12.1)	
Diabetes	5 (12.8)	24 (13.9)	
Bariatrics	6 (15.4)	14 (8.1)	
Infectious diseases	1 (2.6)	4 (2.3)	
Allergy	3 (7.7)	1 (0.5)	
Oncology	0 (0.0)	11 (6.4)	
Access to Internet at home	39 (100)	-	-
Access to Internet via:		_	_
Smartphone	34 (87.1)		
Home computer	34 (87.1)		
Tablet	22 (56.4)		
Technology Readiness Index (TRI) score: median (IQR)	3.1 (2.6–3.5)	_	-
Experience of food diaries	27 (69.2)	-	_
Of which electronic	19 (48.7)		

#### TABLE 1 (Continued)

Patient characteristic	Consented, <i>n</i> = 39 <i>n</i> (%)	Declined, <i>n</i> = 173 <i>n</i> (%)	p value*
Previous dietetic appointments	22 (56.4)	-	-
Baseline PAM level (median, IQR)	3 (IQR = 3–4)	_	_

Note: IMD where 1 is least deprived.

Abbreviations: IMD, index of multiple deprivation; IQR, interquartile range; PAM, patient activation measure.

\*Where p < 0.05 is considered significantly different.

<b>TABLE 2</b> Characteristics of	dietitian j	participants	( <b>n</b> = 1	11)	)
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Characteristic	n (%)
Female, <i>n</i> (%)	9 (81.8%)
AfC grading band	
5	2 (18%)
6	5 (45%)
7	4 (36%)
	Years (median, range)
Since qualification	4 (1.25–25)
In current role	2 (0.1–10.8)

Abbreviation: AfC, Agenda for Change.

lowest in renal and oncology. Illness was the most common reason for non-participation in these areas. Further details of the patient recruits including baseline questionnaire scores are also shown in Table 1.

# Intervention

Usability of myfood24 software for recording dietary recalls prior to OPA

Table 3 provides details of patient completion rates and usability scores for myfood24 dietary recalls. Twenty-nine (74.4%) patients completed at least three 24-h recalls as requested. Seven (17.9%) completed no recall as a result of technology issues or health issues. It was not possible to assess for statistical differences between completers and non-completers because of the low numbers involved; however, non-completers had lower TRI scores.

The mean usability score of the myfood24 software for patients was 67.5 (95% confidence interval = 58.9-76.1). Scores of 60-69 are categorised as marginally acceptable.

The majority of patients completed the recalls using a computer. The estimated time to complete one recall ranged from 21 to 30 min.

#### TABLE 3 Patient usage and usability of myfood24

	n (%)
Number of food recalls completed per patient	
0	7 (17.9)
1–2	3 (7.7)
3	14 (35.9)
>3	15 (38.5)
Reason for non-completion	
Website issues	3
Psychological or physical health	3
Not known	1
Estimated time taken to complete one recall (range)	21–30 min
Device used to complete dietary recall	
Home computer	17 (53)
Smartphone	6 (19)
Tablet	4 (13)
Other	1 (3)
System usability scale (SUS)	
Returned questionnaire	29 (91)
SUS score mean, 95% CI	67.5 (58.9–76.1)

Abbreviations: CI, confidence interval; SUS, system usability scale.

# Usability of myfood24 software as an alternative method for dietary assessment

Table 4 provides responses to the consultation experience questionnaire, completed by dietitians after every appointment. Not all respondents answered all the questions. The median time it took to review patient data prior to each appointment was 15 min compared to an estimated median time of 2 min for usual care.

The majority of dietitians perceived the tool to provide an accurate assessment of type, amount, and meal pattern. Around one-third of consultations were of shorter duration than usual, by an average of 13 min. In half of the appointments, the proportion of time spent on assessment reduced and more time was spent on education.

# Acceptability of the intervention

The acceptability questionnaire completed by both patients and dietitians was used to assess the perceived acceptability of the whole intervention. A maximum score of 50 indicates high acceptability. Median acceptability score for dietitians was 31 (IQR = 30.5-35.5) (n = 11, 100% response rate) and for patients was 39 (IQR 32–42) (n = 26, 81% response rate). Further examination of the responses to each individual

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question based on different constructs of acceptability<sup>30</sup> indicated that, compared to dietitians, the patients found the intervention less of a burden, a more effective use of time and a more positive and successful experience (see Supporting information, Doc. S1).

Further insight into the acceptability of the intervention for dietitians and patients comes from a range of data, including that already reported and findings from interviews and focus groups discussed later.

# **INTERVIEWS AND FOCUS** GROUPS

# **Characteristics of participants**

Twenty patients who attended an OPA were invited for interview and fifteen consented to take part. Two had not completed any recalls using myfood24. All clinical areas were represented and no differences in demographic characteristics or acceptability scores of those interviewed were found compared to the whole study population; however, their mean SUS (74.0) was higher.

Ten dietitians attended one of the focus groups.

# Themes

Thematic analysis of interviews and focus groups relating to the acceptability and usability myfood24 in routine dietetic care identified the following themes: usability of software for clinical care, accuracy of assessment method, and consultation experience. The consultation experience includes the subthemes: preparation, use of website, time management, and relationships and engagement. Data from the patient semistructured interviews and dietitian focus groups are reported separately in relation to the first two themes; however, they have been integrated for the third theme, consultation experience, to show the interaction between the two groups of participants.

# Usability of software for clinical care

# Patient experience

Both of the non-completers experienced difficulties in accessing their account or inputting data. Some completers also struggled because of software glitches. These problems led non-completers to feel worried and overwhelmed.

> It won't accept any passwords or anything our computer. So, we've called it a day at the moment (Interview 1 non-completer)

> The difficulty was you go into bread and there's so many breads. It was very confusing for me honestly (Interview 9 non-completer)

#### **TABLE 4** Distitians responses from consultation experience questionnaire (n = 29)

		n (%)		
Dietitian reviewed patient data		26 (90%)		
Estimated time taken to review data		Median = 15 min		
		(Range 10–30 min)		
Dietitian agreed myfood24 provided accurate record of				
Type of food eaten	23 (79.3%)			
Amount of food eaten	23 (79.3%)			
Meal pattern	24 (82.8%)			
Which dietary assessment method would have been previously used?				
Typical day		20 (69%)		
24-h recall		9 (31%)		
Change in duration of consultation	Took more time	Same	Took less time	
compared to usual: $n$ (%) ( $n = 27$ )	3 (11%)	14 (52%)	10 (37%)	
	Mean change		Mean change	
	+10 min		-13 min	
Change in proportion of time spent on: $(n = 27)$	Spent more time than usual	No change	Spent less time than usual	
Assessment n (%)	7 (27%)	5 (19%)	14 (54%)	
Education <i>n</i> (%)	15 (58%)	5 (19%)	6 (23%)	
Action planning <i>n</i> (%)	5 (19%)	16 (62%)	5 (19%)	

Once logged on, inputting food intake digitally was viewed positively overall by completers, with just one person preferring a paper system. The website and functions received mixed feedback by patients and dietitians. Several dietitians noted the need for more world foods in the database.

Experience improved when instructions and tips were followed, and the website functions were used. Prior practice of recording food intake aided use. Completing recalls was found to be more difficult when cooking from scratch, eating away from home, or eating a wide variety of foods. Limited technology skills and lack of knowledge of food portion sizes also caused difficulties.

The web-based nature of the tool meant that patients could not record food in real time and the majority recorded at least some of their intake on paper and transferred it to the website. Over half said that this was a barrier to future use.

There isn't an app. You have to go to the website. Having it more accessible on the go, I'd probably use it a lot more rather than having to sit down at end of day and think back. Not everyone can sit down at a computer three times a day and input stuff (Interview 14)

Receiving the nutritional analysis reports and the opportunity to discuss their results with the dietitian were the main motivators to completion. Patients reported increased confidence and motivation, and feeling better informed, reassured, and more in control after looking at the analysis.

> I've been extremely busy at work, but I have made time for this 'cos it has been very beneficial for me. It's helped me a lot because I can look at things in more detail' (Interview 3)

However, for some, the reports led to feelings of uncertainty around what they should be reviewing or eating and more individualised guidance on what was relevant to their clinical condition was requested.

> So that much detail was unnecessary for diabetes. Maybe for some things it's important to get the full detail (Interview 8)

Preferences varied for the format of the nutritional analysis displays, so having a range of formats was appreciated. Improvements suggested by patients included being able to view their food intake and nutritional data together; to receive nutritional data in real time rather than just on submission of a complete 24 h; and being able to individualise the fixed recommended nutrient intakes to their needs.

#### Dietitian experience

Dietitians were unanimously negative about the nutritional analysis spreadsheets. They found the data was too detailed for their needs and took too much time to navigate, filter, and make meaningful, leaving little time to interpret it.

> I found it time consuming in terms of, because of the spread sheet you get all the different nutrients, a lot of ones people haven't even heard of. I found that it is a lot of highlighting tabs and deleting out things that are irrelevant (Focus Group 2: 5)

They requested similar improvements to the reporting to the patient group. Further ideas included having specific reports for different clinical condition and expanding feedback for users to include, for example, top food contributors of different nutrients and suggested food swaps. Some felt that given the time and effort required, it would be easier to use the usual pen and paper method.

> 'used Carbs and Cals for portion estimation and still provided all that was required without the website and stress for the patient. I'm not sure in that time whether myfood24 would have given me any better information than that' (Focus Group 2: 4)

# Accuracy of assessment method

# Patient experience

Having the opportunity to receive tailored dietary advice was for some patients a motivation to provide an accurate food record.

> I think that is what you need to stress to people, the more accurate the information you put in there, the more accurate the feedback will be. Then the person I was seeing could give me the best advice based on what I was eating. That's why I did it (Interview 12)

To achieve accuracy, patients felt recording in real time, either on paper or directly on to the website helped, as did website features including visual food portion size guides, handy measure descriptors, and missing item prompts. Only two people mentioned weighing their portions.

# Dietitian experience

Patients and dietitians felt more specialist dietary products were needed on the database and that guidance on making appropriate food substitutions was needed. Some felt unsure about the level of detail that needed to be recorded in the food log. For example, whether it was necessary for an individual to log fluids and low energy dense foods such as vegetables and spices.

> ... it doesn't have specialist gluten free products on there, which ultimately would be a massive issue in terms of assessing adherence ... Again, with gluten free it would be analysis of those specific products that are higher in calcium and things (Focus group 2:3)

Overall, dietitians felt the system was likely to provide a more accurate record of food intake than current practices for various reasons including more authentic food recalls and the software analysis.

Rather than coming to clinic and giving the perfect diet history and us saying 'oh that sounds alright' because that's all they have told you. I think she was maybe a bit more honest. I think maybe she felt like because it's a computer system, you are not being judged in the same way, so she just put it in' (Focus Group 1:1)

Dietitians felt it important to acknowledge that the data was merely a starting point and had limitations. Skill was required to assess for accuracy, relevance, and missing data.

> We will do guesstimates of macronutrients from a diet history but you kind of know they are estimates. But when it comes out with a hard printed copy that says you've had this many calories, this much protein, this many milligrams of calcium, it feels more solid doesn't it? It's making sure you interpret it correctly, remembering the inaccuracies of the process' (Focus Group 2:6)

# The consultation experience

# Preparation

Preparation was found to be time consuming and, in future, dietitians would want time allocated for this. However, this was felt to be key to effective use of the data in the consultation. Less experienced dietitians found having this information in advance particularly helpful, although one felt this risked judging patients in advance of meeting them.

Even before I was going there, I was thinking this is going to be really tough. This is going to be really difficult, and I think that as a dietitian, it can make you a bit biased about how the consultation is going to go (Focus Group 2:8)

# Use of website

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Dietitians and patients mostly reviewed the data together, either using the website (face-to-face and phone appointments) or reports that dietitians had generated. The visual displays were used as an educational tool and raised discussions on food swaps, portion sizes and sources of specific nutrients. Patients appreciated that the dietitian had reviewed and considered their data beforehand and could help to explain it.

Patients were dissatisfied when dietitians, mainly because of technical problems, did not review their data or share it in appointments.

# Time management

Dietitians experience on the impact of the tool on time management in the OPA was mixed.

Time was needed to discuss issues when things did not go to plan with the tool.

It made the consultation difficult because she was disappointed in herself that she hasn't been able to fill it in before she came so it was a negative impact to the consultation (Focus Group 2:6)

Having more tailored reports was requested by both groups, to help keep the focus and avoid taking up time discussing parts of the reports that were not relevant to the referral.

Dietitians found they became more efficient as they became familiar with the new process in appointments, and not doing a dietary assessment saved time for some.

Appointments were described by patients as time efficient, personalised and providing time for discussion and education. Some felt future appointments could be shorter or less often.

# Relationships

The impact on therapeutic relationships was positive. Dietitians sensed that patients felt more at ease, due in part to not being put 'on the spot' or having questions 'fired' at them. This was noticed particularly with people with chronic conditions. They were able to take charge of their diet history as opposed to 'oh now I have to tell the dietitian right now everything that I have had to eat'. So, I think it made her feel more relaxed having done it from home before (Focus Group 1:1)

It also makes you think about what you've eaten before, so you aren't just sat there 'umming' and 'arrrhing' when you are going through the interview part (Interview 8)

# Engagement

In addition to the tool being used for dietary assessment and education, it was also helpful for engaging people in self-care. Dietitians found this aspect a positive experience, which brought about a noticeable shift in self-management behaviours and motivation. Improvements in health literacy and ownership of the dietary assessment were more apparent because patients gave their views of the current situation and potential changes. Patients noted how they felt more confident to review their data at home after the consultation.

> She was the one who said, 'oh I could have done with having more protein in my diet' and she could see that from the graph. It was like she had taken more ownership of it. Because she had figured it out before she had come, so the ball was in her court a little bit as well. That was good (Focus Group 1:1)

Patients acknowledged that they had not appreciated the benefits of this intervention beforehand and felt promoting these in advance to encourage its use as standard practice, not an additional extra, would be valuable.

# DISCUSSION

# Main findings

The present study demonstrates that, even after a brief trial of a digital dietary assessment tool in clinical practice, it is feasible to use it as an aid to clinical care. Dietitians and patients found this new type of care moderately acceptable, although patients found it a more positive experience and a better use of their time compared to the dietitians. Dietitians' experiences were affected largely by the unsuitability of the software for this setting. Patients and dietitians were positive about the new type of consultation, which showed the potential to improve quality of care and save time in some clinicals situations.

# Strengths and limitations of the study

Recruitment rates of patients were lower than hoped as a result of under-recruiting in certain clinical areas. Consequently, this limited the experience for some dietitians.

The demographics of the study population were representative of the clinic population and were diverse in relation to age, sex, and socio-economic status, but not ethnicity. The PAM score of recruits suggested that they engaged in self-care and may not be typical of the whole clinic population. There was a low dropout rate for the intervention and questionnaire return rates were good. Interviewees were demographically diverse and included non-completers. However, post-interview analysis showed that interviewees had higher usability scores compared to the sample as a whole.

The mixed method study design and detailed screening and recruitment data led to a rich dataset, which contributed to achieving the research aim.

# Comparison with the existing literature

The present study sought to build on findings from previous myfood24 studies by using the assessment tool for the first time as part of the dietetic care process to assess its feasibility. To our knowledge, there are no UK studies that have examined the use of digital dietary assessment tools in clinical care, with most related research taking place in Australia<sup>12</sup>; however, there have been UK studies in non-clinical populations.<sup>8,31,32</sup>

A previous clinical study suggested that the way an intervention is introduced to patients is important for engagement.<sup>12</sup> In the present study, only 18% of the clinic population participated, which may indicate that our introduction needs further thought to engage a higher proportion of participants.

Previous myfood24 studies in non-clinical settings<sup>8,31,32</sup> have reported SUS scores of above 70 ('good'), which is higher than those found in the present study where usability was categorised as marginally acceptable. This suggests that patients did not find the myfood24 software as easy to understand and use compared to participants in non-clinical settings. There are a number of things that could have contributed to this. The TRI scores of our population were lower than reported elsewhere<sup>33</sup> and so could have had an impact. Where patient technology skills are lower, further support may be worthwhile<sup>33</sup> and TRI could potentially be used as a screening tool to identify where to target support. Common usability issues reported were similar to those identified in other digital dietary assessment studies, such as accessing the software, finding the right food on the database, or time concerns.<sup>9,32</sup> As with the present study, patients also felt that these issues impacted on the accuracy of their data input and data output.<sup>12</sup>



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Completion rates for three food recalls were 74% in the present study, which was higher than the 39% reported in a previous study with a non-clinical population.<sup>32</sup> Chen *et al.*<sup>18</sup> suggest that motivation to use software is higher when it is introduced to HCP, there is good rapport between the patient and HCP, and there is the opportunity to share data and receive support from a trustworthy source. Our findings suggest that these factors may have contributed to the high completion rates in the present study.

An international survey of dietitians exploring their views of health apps highlighted a need for tools to be designed for a healthcare setting.<sup>34</sup> Low self-efficacy levels in using digital assessments were found to be another barrier to the use of digital tools by dietitians.<sup>19</sup> In the present study, more recently qualified dietitians reported more substantial concerns about using the software. Overall, most dietitians had few concerns about using it in clinics despite lack of practice. This could reflect the training and support that they received from the researchers and the fact that many were experienced dietitians.

As in other studies, even in this intervention of short duration and small numbers, patients and dietitians reported many positive aspects regarding this new approach in the consultation and the impact on therapeutic relationships and quality of care.<sup>13,35,36</sup> Our data supports findings elsewhere of the real potential for enhancing self-care through improving knowledge, problem-solving abilities, confidence, and motivation.<sup>13</sup>

# IMPLICATIONS FOR FUTURE CARE

This study has demonstrated that this tool was feasible to use and was acceptable as part of clinical care for patients and dietitians. The main concerns for use in future care are the lack of uptake by patients who could benefit, sufficient training and support provision to patients and dietitians, and the need to adapt the software for healthcare. The implication therefore is that this tool and others like it, do have a role in future dietetic care.

# **Recommendations for future development**

Future tools need to continue to improve usability to enable completion of food recalls with minimal support and to ensure that outputs are appropriate for healthcare, as well as supportive of care provision. Recommendations include providing nutritional analysis reports for patients and dietitians that meet individual and service needs, and also providing patient feedback in real time to aid food choice. Involving users in the design of tools is important for achieving this,<sup>19,36</sup> as is expert guidance on tool development.<sup>9</sup> Training for dietitians along with 136

advocacy from the British Dietetic Association is recommended to enable HCP to implement such technologies in practice.<sup>19</sup> Involving users in the development of promotional materials could also aid the uptake of interventions.

# **Recommendations for future research**

Once suitable tools for clinical use are available, studies should examine their impact on patient care further. The cost of developing high quality and effective technologies is high, which will generate upfront costs for the NHS. Their use, however is likely to be cost effective<sup>36</sup> and studies are required to explore this.

Questions remain regarding the practicalities of introducing these tools, such as when and how best to introduce them, who may and may not benefit, optimal number and frequency of recalls, and the impact of observer reporting rather than self-reporting via a carer or other HCP (e.g., a healthcare assistant).<sup>35,37</sup> Validity testing would need to be extended to include specific populations such as people with renal disease by, for example, using biomarkers.<sup>24</sup>

# CONCLUSIONS

To the best of our knowledge, this is the first study to explore the use of a digital dietary assessment tool in clinical practice in the UK and the study found that the use of myfood24, an online 24-h recall dietary tool, was feasible and acceptable for patients and dietitians. Digital dietary assessment tools potentially enable patients to become more autonomous decision makers through improved knowledge of their nutritional intake and this can improve quality of life and increase motivation to self-manage their health.<sup>38</sup> Potential benefits to dietetic care include more accurate dietary assessments, quick access to detailed nutritional analysis, and potential for shorter appointments with more time for patient education. Therefore, these findings are important to the future development of such tools for dietetic practice as recommended in the Future Dietitian 2025 report.<sup>21</sup> Limitations included the low uptake in certain clinical groups and in those with lower technology readiness, as well as the time it takes for patients to complete and for dietitians to review the data. Further software developments are needed prior to formal testing to examine the impact of this tool on treatment satisfaction, behaviour change, clinical outcomes, and cost effectiveness in a clinical setting.

## AUTHOR CONTRIBUTIONS

Carla Gianfrancesco designed and managed the study, undertook data collection, led on qualitative data analysis, and was the main author on the paper. Carolyn Taylor was involved in setting up the study, recruitment, data collection, led on quantitative data analysis, and contributed to the paper. Liz Croot provided advice on the qualitative research study design, was involved in the analysis of the qualitative data, and contributed to the paper.

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## **CONFLICTS OF INTEREST**

Carla Gianfrancesco has served on an advisory panel for myfood24 as a Registered Dietitian and did not receive any financial payment for this. Carolyn Taylor and Liz Croot declare that they have no conflicts of interest.

## ETHICS STATEMENT

Ethical approval was granted by North West-Greater Manchester East REC 19/NW/0411.

# 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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# The 'Tasty School' model is feasible for food education in primary schools

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## Abstract

**Background:** The 'Tasty School' is a tailored teacher-delivered food education model for primary schools in Finland. The aim of the current study was to investigate the feasibility of the Tasty School model in primary schools. Furthermore, the aim was to assess changes during the intervention in the class teachers' perspectives and experiences related to food education and school dining.

**Methods:** The method involved a quasi-experimental study with intervention and control groups. A total of 130 class teachers from 15 intervention and 10 control schools from five municipalities in Finland participated in the study during one school year. The theoretical framework of acceptability was utilised to evaluate feasibility using frequencies. The comparison data were analysed using a mixed-effects model for repeated measures to account for the intervention effects and selected standardising effects.

**Results:** Teachers reported that the model was highly acceptable and easily integrated into the school environment. Support from principals and colleagues was the most important facilitator of food education, and lack of time was the barrier. Teachers in the intervention schools were more likely to consider school meals healthy after the intervention, and they reported having sufficient materials and supplies for food education.

**Conclusions:** The Tasty School was shown to be a feasible model for food education in primary schools. The current study especially found that the commitment of the whole school and principals' role are crucial in the implementation of food education. The factors that support the implementation must be strengthened, and efforts must be made to reduce the barriers.

# **KEYWORDS**

education models, feasibility, food education, schools

#### Key points

- The Tasty School was shown to be a feasible model for food education in primary schools.
- The commitment of the whole school and principal's role are crucial in the implementation of food education.

Aija Liisa Laitinen and Amma Antikainen contributed equally to this work as first authors.

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# INTRODUCTION

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School is a promising arena for promoting healthy eating patterns because it reaches practically all children in Finland.<sup>1,2</sup> Moreover, in Finland a free hot meal is offered daily to all pupils in basic education.<sup>3</sup> The content of the school meals is balanced and healthy because it is based on and guided by the Finnish National Nutrition Council's School Meal Recommendations.<sup>4</sup> The recommendations also guide food education implemented during school dining, suggesting, for example, the social participation of the pupils and of the teaching staff eating together with the pupils. The Finnish National Core Curriculum for Basic Education<sup>5</sup> identifies food education as an essential part of school routines and obligates schools to set objectives for it. However, the curriculum does not provide practical tools or more specific guidance for the implementation of food education in practice.

An earlier study showed that a food education curriculum called 'Tools for Feeling Good' was effective in promoting regular meals, vegetable consumption and eating varied school lunches among fifth graders.<sup>6</sup> Effective food education models have been developed, but establishing food education in normal everyday school practices is challenging.<sup>7,8</sup> Several nutrition and food education interventions have been structured as separate projects apart from the normal routine of primary schools.<sup>9–11</sup>

The 'Tasty School' model provides tools to implement food education in primary schools and thus helps schools to meet the requirements of the School Meal Recommendations<sup>4</sup> and Finnish National Curriculum.<sup>5</sup> The Tasty School model was developed in cooperation with primary schools and nutrition, food education and basic education experts by utilising a previous nutrition curriculum, 'Tools for Feeling Good', as a starting point.<sup>6</sup> The food education model extended the earlier-developed curriculum to cover the entire primary school system (grades 1-6, age 7-12 years) and diversified through a website that included an idea bank with learning materials, self-assessment questionnaire and online training for teachers. The model was based on several theoretical approaches: self-determination theory,<sup>12</sup> health at every size approach,<sup>13</sup> eating competence,<sup>14</sup> sensory-based learning<sup>15</sup> (i.e., Sapere), mindful eating<sup>16</sup> and intuitive eating.<sup>17</sup> The Tasty School has a holistic approach as it integrates food education pedagogy in school subjects, school meals and school environment. At the teachers' level, the aim of the Tasty School model was to increase their knowledge and pedagogical competence in food education through online training and to provide a wide set of tools for evaluating, planning and implementing food education in primary schools.

Our intention was that the Tasty School model would become embedded in both curriculum development and lesson planning, thereby ensuring that food education occurs in the classroom as well as the cafeteria and, furthermore, designating school meals as a pedagogical activity.<sup>18</sup> It is important to understand the elements of effective implementation to establish food education pedagogy in the daily routines of primary schools.<sup>19,20</sup> Thus, we need a broader picture of the Tasty School model's feasibility to promote its establishment, because it is a new, strongly teacher-driven and applied food education model.

The aim of the current study was to investigate the feasibility of the Tasty School food education model in primary schools. Furthermore, the aim was to assess changes during the intervention in the class teachers' perspectives and experiences related to food education and school dining.

# METHODS

The present study had a quasi-experimental design<sup>21</sup> with 15 intervention schools that were supported to implement food education based on the Tasty School model and 13 control schools that did not receive food education support. The study was conducted during the 2019–2020 school year and included baseline and follow-up questionnaires addressed to all class teachers in participating schools. Also, feasibility questionnaire was addressed to teachers in the intervention group after the intervention. The study design was reviewed and approved by the Committee on Research Ethics of the University of Eastern Finland.

# Participants and recruitment

The recruitment process started in January 2019 by contacting the municipalities' directors of education and inviting them to participate in the study. Based on their previous cooperation, six municipalities were contacted, and five municipalities located in southern and eastern Finland finally participated in the study. These municipalities had approximately 10,000–120,000 inhabitants and 83 primary schools.

Schools from participating municipalities were recruited in spring 2019 by the directors of education. The aim was to recruit a maximum of 15 intervention and 15 control schools due to the project's resources. Due to the varied resources of schools, the participating schools were able to choose their status in the study, as either an intervention school or a control school. The directors of education were not willing to order schools to participate, and thus, all forms of participation were known up front. At the end of the recruiting process when the maximum number of intervention schools was already recruited, the rest of the interested schools were invited to participate as control schools. At least one control school was recruited from each participating municipality.

Altogether 15 intervention and 13 control schools participated in the study (Figure 1). Each municipality had at least four participating schools, and all primary schools participated in one municipality. All class teachers in the intervention and control schools were asked to participate, and all of them provided a written consent to participate in the study.

# Implementation of the Tasty School model

The study group introduced the Tasty School model in spring 2019 to the teachers of the intervention schools. All intervention schools were advised to implement a tailored, teacher-delivered Tasty School programme during the school year 2019–2020 from September 2019 to March 2020.

Figure 2 describes the Tasty School intervention activities at the teacher and school levels and the support and materials provided for intervention schools. For each intervention school the starting point of the implementation was to fill in a self-assessment questionnaire at the beginning of the school year concerning the state of their school's food education and school lunch arrangements. The survey covered five themes: management and engagement, integration of food education, implementation of school meals, collaboration and support. The questionnaire was filled by a multiprofessional group. Schools were instructed to invite at least the principal, a teacher and a food service employee into the multi-professional group, but others were also welcomed to participate. Based on the self-assessment questionnaire, each intervention school was advised to choose independently development targets to guide the implementation of the Tasty School model at school level. The self-assessment questionnaire was used only for assessing the current state of food education and setting targets for schools. The information gathered from it was not used as research data.

The schools selected one to two coordinating teachers who encouraged school personnel to implement the Tasty School programme. These coordinating teachers received a 1-day live training on the Tasty School at the beginning of the school year. A member of the study group contacted the coordinating teachers once in a month by email or phone throughout the school year. Each class teacher was instructed to implement at least one food education idea (duration of at least 30 min) monthly in their class (seven ideas per school year). Class teachers were also encouraged to conduct a 3-h online training on food education during the autumn semester.

Teachers were instructed to utilise the Tasty School idea bank, which contained more than 100 development or action ideas for food education in school. These ideas were instructed to be integrated into their schools' daily routines during the intervention year. The idea bank is available at www.maistuvakoulu.fi (only in Finnish). The idea bank had three main sections: ideas for lessons, school dining and collaboration in food education. The ideas were further grouped by topics, such as food culture, food routes, sensory-based learning (Sapere), media literacy, sustainable diets, body image and nutrition and health.



FIGURE 1 Study design, study population and measurements

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**FIGURE 2** The Tasty School intervention activities at the teacher and school levels and the materials and support provided for the intervention schools

During the intervention a monthly newsletter with practical ideas for food education was emailed to all teachers. The Tasty School web page published a monthly food education blog entry with topical issues and tips. Weekly food education tips were posted on the Tasty School Facebook and Instagram pages. Schools received a copy of the Finnish Recommendations for School Meals and a toolkit for sensory-based food education activities (e.g., smelling bottles, basic tastes in white powder form and bags for touching with printed handbook). The schools received no financial support.

# Assessments

# Evaluation of implementation and feasibility

Implementation fidelity, referring to the degree to which the intervention was delivered as intended,<sup>22</sup> was evaluated monthly during the intervention via electronic questionnaires targeted only at the intervention group. Class teachers reported the quantity and nature of food education activities they had conducted and the time spent on food education. Through the questionnaires, teachers reported how many and what kinds of activities they had completed during each month.

Feasibility, including acceptability and implementation fidelity of the Tasty School model, was also evaluated. A feasibility questionnaire was directed to the teachers after the intervention to investigate how well suited the model is to the school routines and work of teachers. The theoretical framework of acceptability, comprising seven components (affective attitude, burden, perceived effectiveness, ethicality, intervention coherence, opportunity costs and self-efficacy), was utilised.<sup>23</sup> In addition, implementation barriers and facilitators were evaluated with a query that included 16 statements. All questions were asked using a five-point Likert-scale: totally disagree, somewhat disagree, neither agree nor disagree, somewhat agree and totally agree, scored 1, 2, 3, 4 and 5. The feasibility questionnaire was pre-tested before it was implemented. About 20 people participated in the pre-testing.

All principals (n = 15) of the intervention and control schools (n = 10) were personally interviewed by phone after the intervention in June or October 2020. In the interviews principals were asked (1) whether the Tasty School model was included in the school year plan, (2) whether food education projects in which the entire school participated were implemented during the previous school year, (3) whether any positive changes were noticed at school (subjective evaluation) and (4) whether the school intended to take advantage of the Tasty School model next school year. Also, an opportunity to give open feedback was provided.

# Teachers' perspectives and experiences of food education and school dining

All class teachers in the intervention and control schools were invited to answer an electronic baseline questionnaire at the beginning of the school year in August 2019 and an electronic follow-up questionnaire in April 2020. Three control schools dropped out due to the COVID-19 pandemic before the follow-up measures. Supporting Information, Table 1, presents descriptive information on the participating teachers.

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The perspectives and experiences on both food education and school dining were evaluated using 15 statements. The statements in the school dining query were based on a previously used questionnaire<sup>24</sup> (Supporting Information, Table 2). These statements were evaluated using a five-point Likert scale: totally disagree, somewhat disagree, neither agree nor disagree, somewhat agree and totally agree, scored 1, 2, 3, 4 and 5. The food education query, developed by the study group, included the following themes: 'resources available for food education' (financial resources, time and materials), 'support', 'self-efficacy concerning food education as a part of school teaching', 'importance of food education at school and as a part of teacher's work' and 'effects of food education on pupil's health and well-being'.

# Statistical analysis

Statistical data analysis was performed using SPSS (IBM SPSS, version 27.0, 2020). Descriptive statistics (means, standard deviations and frequencies) were calculated separately for baseline, follow-up and feasibility questionnaires. More complex statistical analysis was enrolled for comparing changes in teachers' perspectives and experiences between intervention and control schools. The criterion for significance was set to be p < 0.05. Associations with statement variables, measured using the five-point Likert scale, and explanatory variables were analysed using linear mixed-effects models for repeated measures due to a two-level data structure by clustering the repeated outcome measures at baseline and follow-up within teachers. Intervention versus control was examined (two groups). The model was adjusted for fixed effects of sex and teaching experience and included main effects for time and two-level intervention group with intervention group × time interaction. The only random effect in the model, in addition to repeated structure, was the teacher-specific intercept. Clustering within schools was tested in the analysis, but it did not have significant effect on the results, and thus, in the means of model simplicity, it was excluded from the final model. Normality and independence of residuals, assumed by the mixed model, were confirmed with visual inspection of histograms and autocorrelation plots of the residual, respectively.

# **Dropout analysis**

Dropout analysis was conducted using the Mann–Whitney U-test to examine possible selection bias between teachers (n = 115) who dropped out after the baseline and teachers (n = 130) who remained in the study. No significant differences were found in any of the descriptive or outcome variables.

# RESULTS

# Feasibility evaluation through acceptability and implementation fidelity

There were 153 class teachers in the intervention schools. Teachers implemented an average of three food education activities during the school year (mean 3.0, standard deviation 2.2, min 0, max 7). A total of 11% (n=17) of the teachers never answered the monthly report or did not implement any food education activities during school year.

After the intervention, 88 teachers (58%) in the intervention schools answered the feasibility questionnaire concerning user experiences and perceptions of feasibility and acceptability of the model. Online training was fully completed by 60% (*n* = 53) and partially completed by 15%(n = 13). Overall 96% (n = 84) reported they had utilised the Tasty School's food education idea bank during the school year. The Tasty School's feasibility and acceptability was high: 80% (n = 70) of teachers reported they were also going to use the Tasty School next year, 80% (n = 70) would recommend the model to colleagues, 90% (n = 79) felt that Tasty School's ideas have helped to put food education into practice and 85% (n = 74) said that Tasty School had benefitted the school's teaching (Supporting Information, Table 3). One-fourth (25%, n = 22) of the teachers felt that the Tasty School has increased cooperation with pupils' parents. Principals' interviews indicated that 80% of the intervention schools aimed to continue implementing the Tasty School next year.

# Facilitators for and barriers to implementing Tasty School model

The most important implementation facilitators were support from principals and colleagues, and the Tasty School can be used based on the teachers' own needs and interests (Figure 3). The model was also reported to be highly suitable for the school environment: only 1% (n = 1) of the teachers neither agree nor disagree that the Tasty School model is appropriate for the school setting. The reported barriers (Figure 4) were the lack of time (53%, n = 47, of teachers), financial resources (30%, n = 26, of teachers), difficulties in work planning (25%, n = 22, of teachers) and suitable room/space for food education (17%, n = 15, of teachers).

# Comparison of teachers' perspectives and experiences between the intervention and control groups

The study sample comprised 130 teachers from intervention and control schools who had answered questionnaires both at baseline and at follow-up (Figure 1).





FIGURE 3 Facilitators for implementing the Tasty School model according to the experiences of class teachers



FIGURE 4 Barriers to implementing the Tasty School model according to the experiences of class teachers

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# Food education

At baseline, 92% (n = 119) of teachers agreed that the school has an important role in their pupils' food education, and 89% (n = 116) of teachers agreed that class teachers are important food educators for pupils. Teachers in the intervention schools (n = 82) experienced an increase in their resources for implementing food education during the intervention (Table 1). The teachers reported that they received greater support from the work community and had sufficient learning materials and supplies to implement food education at the end of the intervention. Furthermore, they agreed that food education can affect their pupils' well-being. More modest or even opposite changes were observed in the control group (n = 48).

# School dining

At baseline, 71% (n = 91) of teachers agreed that school meals are tasty, 70% (n = 90) of teachers agreed that school lunch is a nice moment in a day and 61% (n = 79) of teachers agreed that it is cosy in the dining hall, but 57% (n = 73) of teachers disagreed that they have enough time to eat, and only 24% (n = 31) of teachers agreed that there is not too much noise in the dining hall. Teachers reported that they have 14 min to eat school lunch (n = 127, mean: 13.6 min, standard deviation: 4.3, min: 5 and max: 30). The reported time does not include the time it takes to queue and take food.

The teachers' experience participating in planning school dining was low; 63% (n = 52) of teachers in the intervention group and 69% (n = 33) of teachers in the control group disagreed with the statement, 'I get to participate in planning school dining'.

The opinion that school meals are healthy strengthened (p = 0.012, mean before 4.25 and mean after 4.33) in the intervention schools after the intervention, whereas this opinion weakened (mean before 4.23 and mean after 4.02) in the control group. There were no other statistically significant changes between the teachers of intervention and control schools in their perspectives and experiences of school dining (Supporting Information, Table 2).

# DISCUSSION

Research data on food education embedded in normal school operation are limited. The current study implemented the Tasty School model that focused on integrating food education into the school curriculum, culture and daily pedagogical activity. The current study has a pioneering role because of the nature of the implemented model. The model sought to promote a holistic approach to food education with diverse themes and perspectives. HND

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The feasibility of the Tasty School model was high among the teachers. The model was developed in collaboration with teachers, which has likely increased engagement and feasibility.<sup>25,26</sup> A further reason for its high feasibility may be that the teachers were able to implement the model according to the needs of their class or school.<sup>27</sup> According to self-determination theory,<sup>12</sup> the model emphasised teacher autonomy and applicability to different kinds of schools and teachers.

The most important implementation facilitator perceived was support from the principals and colleagues. A previous study from the United States reported similarly that teachers need support from school principals to implement nutrition education.<sup>28</sup> The implementation of the Tasty School model increased the experienced support from work community for food education. It is important that the whole school staff is committed to the implementation of food education, including the principal, who seems to have a crucial role. The themes of food education are diverse and connect to different subjects, including school dining and overall well-being and sustainability.<sup>29</sup> Thus, food education cannot be effective if only some of the teachers are interested and involved.

The major barriers to implementing the Tasty School model were lack of time and financial resources and difficulties in work planning. Previous studies have identified similar kinds of barriers for school food education, including teachers' heavy workload, lack of a universal and systematic model or curriculum, lack of common objectives of food education and lack of continuous nutrition training for teachers.<sup>20,30</sup> The current study shows that limited opportunities for teachers to participate in planning school dining also are a clear challenge for enhancing pupils' social participation in school dining. Defining objectives for food education, active planning and implementation are needed to overcome these difficulties and to achieve sustaining positive effects and efficiency. One way to increase teachers' activity in food education in the future may be to strengthen teachers' views on the pedagogical possibilities of school dining through education, national regulations and guidelines.<sup>18</sup>

At baseline, the teachers in both the intervention and control schools already considered the role of food education in schools important. After the intervention, teachers in the intervention group felt more often that the well-being of pupils can be influenced by food education, whereas this conviction weakened in the control group. The Tasty School model provided teachers' sufficient supplies, learning materials and exercises to implement food education. A favourable change can be observed although the amount of implemented food education activities did not fulfil the original aim and up to 40% of the teachers in the intervention schools did not complete the online training. This significant change also emerged even though intervention schools received no financial support, only the Tasty School website and a toolkit for - JHND

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Statement <sup>a</sup> (min 1, max 5)	Intervention group $(n = 82)$	Control group $(n = 48)$	<i>p</i> -Value <sup>b</sup>
The school has an importan	t role in food education of pu	pils	P + ulue
Mean at baseline (SD)	4.35 (0.71)	4.19 (0.76)	0.009
Mean at follow-up (SD)	4.40 (0.54)	4.23 (0.81)	0.908
Class teachers are importan	t food educators for pupils		
Mean at baseline (SD)	4.30 (0.70)	4.04 (0.77)	0.874
Mean at follow-up (SD)	4.35 (0.61)	4.13 (0.89)	0.074
Food education can affect p	upils' well-being		
Mean at baseline (SD)	4.40 (0.65)	4.44 (0.62)	0.017
Mean at follow-up (SD)	4.57 (0.52)	4.27 (0.82)	0.017
Food education can affect w	vell-being by promoting pupils	' healthy eating habits	
Mean at baseline (SD)	4.46 (0.53)	4.38 (0.64)	0.608
Mean at follow-up (SD)	4.39 (0.56)	4.23 (0.83)	0.000
Food education is an import	tant part of my work		
Mean at baseline (SD)	3.85 (1.00)	3.90 (0.90)	0.129
Mean at follow-up (SD)	3.99 (0.82)	3.75 (1.00)	0.129
I am interested in developin	g food education in (my) sch	ool	
Mean at baseline (SD)	3.91 (0.89)	3.52 (1.01)	0 472
Mean at follow-up (SD)	3.70 (0.89)	3.42 (1.09)	
I feellbelieve that I can mak	ce an impact on my pupils' we	ell-being by food education	
Mean at baseline (SD)	3.74 (0.78)	3.50 (1.11)	0.459
Mean at follow-up (SD)	3.79 (0.68)	3.67 (0.91)	
I have experienced that I can	n affect well-being by promotin	ng pupils' eating habits with	food education
Mean at baseline (SD)	3.65 (0.88)	3.58 (0.96)	0.610
Mean at follow-up (SD)	3.76 (0.73)	3.60 (0.92)	
I trust that I have sufficient	competence to implement for	od education	
Mean at baseline (SD)	3.96 (0.76)	4.10 (0.88)	0.212
Mean at follow-up (SD)	4.17 (0.70)	4.13 (0.79)	
I feellbelieve that I can imp	lement food education as part	of my job	
Mean at baseline (SD)	3.74 (0.89)	3.81 (0.92)	0.293
Mean at follow-up (SD)	3.91 (0.79)	3.79 (0.90)	
I have sufficient learning ma	aterials and exercises to imple	ement food education	
Mean at baseline (SD)	2.90 (1.17)	3.06 (1.17)	<0.001
Mean at follow-up (SD)	4.26 (0.68)	3.27 (1.09)	
I have sufficient supplies to	implement food education		
Mean at baseline (SD)	2.51 (1.11)	2.71 (1.15)	<0.001
Mean at follow-up (SD)	3.45 (1.06)	2.90 (1.06)	
It is possible for me to obta	in paid material for the imple	mentation of food education	on
Mean at baseline (SD)	2.26 (1.02)	2.08 (0.92)	0.562

**TABLE 1**Statistical comparison ofteachers' perspectives and experiences offood education

Statement <sup>a</sup> (min 1, max 5)	Intervention group ( <i>n</i> = 82)	Control group $(n = 48)$	<i>p</i> -Value <sup>b</sup>
Mean at follow-up (SD)	2.18 (1.03)	2.12 (0.98)	
I have sufficient time to impl	lement food education		
Mean at baseline (SD)	2.48 (1.10)	2.52 (1.07)	0.500
Mean at follow-up (SD)	2.49 (1.10)	2.67 (1.02)	
I receive sufficient support for	or my food education work in	my work community	
Mean at baseline (SD)	3.18 (0.90)	3.31 (0.99)	<0.001
Mean at follow-up (SD)	3.83 (0.81)	3.13 (0.91)	

Abbreviation: SD, standard deviation.

<sup>a</sup>Perspectives on food education at school were evaluated using a 15-item query with a five-point Likert-scale: totally disagree, somewhat disagree, neither agree nor disagree, somewhat agree and totally agree.

<sup>b</sup>*p*-Value of the interaction. The data were analysed using a mixed-effects model for repeated measures

accounting for the intervention effect and selected standardising effects.

sensory-based food education. The findings of the present study suggest that the Tasty School model can increase teachers' knowledge and pedagogical competence in food education, and more active participation could further support Tasty School's implementation.<sup>31</sup>

The opinion that school meals are healthy decreased in the control group, whereas the intervention strengthened this view in those teachers. Finnish school meals commonly include everyday dishes, and their nutritional quality is guided by the School Meal Recommendations,<sup>4</sup> which are based on the Finnish Dietary Recommendations.<sup>32</sup> Thus, school meals can objectively be kept healthy. Increased opinions school meals being healthy, might reflect also increased positive attitude towards school dining overall. One might also question whether teachers' nutritional knowledge has increased.<sup>33</sup>

The implementation of the model did not focus on increasing cooperation between school personnel and pupils' parents; neither was the amount of cooperation measured in the current study. Involving parents more could support food education and thus further enhance well-being, nutrition and food literacy not only in the school environment but also in the home environment.<sup>31,34</sup> This is one aspect that the Tasty School model could further develop in the future.

A strength of the current study was its intervention–control setting. The research data were also collected extensively across Finland; thus, the results do not feature only a particular area. Furthermore, the research schools varied in sizes and operated in several municipalities, so the results are not the result of an individual municipality's resources or curriculum.

The study has a few limitations. As a quasiexperimental study, the study frame might be exposed to selection bias. Participating schools could choose whether they want to participate as an intervention or control school; thus, schools were not randomised into the research groups.

The intervention study was conducted in the school year 2019-2020 during which the COVID-19 pandemic emerged and forced schools to shift into remote teaching 1 month before the follow-up measurements. This might have impacted teachers' resources and thus the implementation intensity of food education. However, the intervention-control study design likely alleviated these possible effects. The COVID-19 pandemic also affected the dropout rates, especially in the control group but less in the intervention group, which could reflect their higher commitment to the study. Unfortunately, the pandemic influenced so that 42% of teachers in the intervention group did not answer the feasibility questionnaire. Because the response rate at follow-up was quite low, it is therefore possible that teachers with the most positive attitudes towards the Tasty School model answered the follow-up and feasibility questionnaire. However, the baseline dropout analysis found no significant differences between the teachers who dropped out and those who completed the study.

In conclusion, the Tasty School food education model offers a promising tool to primary schools in Finland. The elements of the model could also be applied in other countries. Collaboration with teachers in the development of the Tasty School is likely to enhance its feasibility and teachers' commitment to implement it. To promote the implementation of food education, factors that support the implementation, like commitment of the whole school and suitable premises as well as financial resources, must be strengthened, and efforts must be made to reduce the barriers. Teachers also need direction and support from principals to implement food education. The current study especially shows that the commitment of the whole school and principal's role are crucial and that future research should focus on identifying the facilitators for and barriers to implementing food education in primary schools, particularly from the view of principals and education administration.

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# AUTHOR CONTRIBUTIONS

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Tanja Tilles-Tirkkonen, Amma Antikainen, Kaisa Kähkönen, Sanna Talvia, Leila Karhunen and Aija Liisa Laitinen were responsible for study conceptualisation and methodology. Amma Antikainen, Aija Liisa Laitinen and Tanja Tilles-Tirkkonen were responsible for data curation. Amma Antikainen, Kaisa Kähkönen, Silja Varjonen, Saila Paavola and Tanja Tilles-Tirkkonen were responsible for investigation and data collection. Santtu Mikkonen conceived the concept for the analysis. Santtu Mikkonen, Amma Antikainen and Aija Liisa Laitinen conducted statistical analysis. Aija Liisa Laitinen and Amma Antikainen are the principal authors of the manuscript. Aija Liisa Laitinen, Amma Antikainen and Tanja Tilles-Tirkkonen were responsible for preparing the original draft. Santtu Mikkonen, Kaisa Kähkönen, Sanna Talvia, Silja Varjonen, Saila Paavola and Leila Karhunen were responsible for reviewing and editing the manuscript. Tanja Tilles-Tirkkonen was responsible for supervision and project administration. All authors have read and agreed to the published version of the manuscript.

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# **CONFLICT OF INTEREST**

The authors declare no conflict of interest.

# TRANSPARENT PEER REVIEW

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 as planned have been explained.

# ETHICS STATEMENT

The study design was reviewed and approved by the Committee on Research Ethics of the University of Eastern Finland.

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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 SUPPORT AND ASSESSMENT

# Estimating nitrate intake in the Australian diet: Design and validation of a food frequency questionnaire

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# Abstract

Background: Dietary nitrates may play a role in mediating several key physiological processes impacting health and/or exercise performance. However, current methods for assessing dietary nitrate  $(NO_3)$  consumption are inadequate. The present study aimed to examine the dietary nitrate intake in a sample of 50 healthy adults, as well as test the validity of a purposefully developed food frequency questionnaire (FFQ).

Methods: Dietary nitrate intake was estimated over a week using (i) three 24-h dietary recalls; (ii) a short-term (7-day) FFQ; and (iii) a biomarker (urinary nitrate), in conjunction with a nitrate reference database.

Results: Daily dietary nitrate intake estimates were 130.94 mg (average of three 24-h recalls) and 180.62 mg (FFQ). The mean urinary NO<sub>3</sub><sup>-</sup> excretion was 1974.79  $\mu$ mol day<sup>-1</sup> (or 917.9  $\mu$ mol L<sup>-1</sup>). Despite the difference between the two dietary assessment methods, there was a moderate positive correlation  $(r = 0.736, \rho < 0.001)$  between the two tools. There was also a positive correlation between urinary NO<sub>3</sub><sup>-</sup> and 24-h recall data (r = 0.632,  $\rho < 0.001$ ), as well as between urinary NO<sub>3</sub><sup>-</sup> and FFQ (r = 0.579,  $\rho < 0.001$ ).

Conclusions: The ability to accurately estimate nitrate intakes depends on having suitable reference methods to estimate the concentrations of nitrate in the food supply, coupled with valid and reliable dietary assessment tools. Based on the findings from the present study, at an individual level, dietary recalls or records may be more accurate in estimating intakes of  $NO_3^{-1}$ . However, given the lower cost and time needed for administration relative to recalls, the FFQ has merit for estimating NO<sub>3</sub><sup>-</sup> intakes in health interventions, dietary surveys and surveillance programs.

#### **KEYWORDS**

database, dietary assessment, dietary nitrate intake, food frequency questionnaire, urinary nitrate

#### Key points

- Nitrate occurs naturally in plant foods and water, and are also commonly used as food additives in cured products. Dietary nitrates may be beneficial for health and exercise performance; however, current methods to assess dietary nitrate consumption are inadequate.
- Estimates of nitrate intake from our purposefully designed food frequency questionnaire showed moderate associations with estimates from 24-h food recalls, as well as from a urinary biomarker.

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• At an individual level, dietary recalls or records may be more accurate in estimating dietary nitrate intake. However, the food frequency question-naire developed in the present study may be useful to estimate nitrate intake in health interventions, dietary surveys and surveillance programs.

# **INTRODUCTION**

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Nitrates  $(NO_3^-)$  occur naturally in plant foods (e.g., vegetables) and water, and are also commonly used as food additives in cured (animal-derived) products, primarily to prevent bacterial growth and improve the microbiological safety of these foods.<sup>1–3</sup> Traditionally, dietary  $NO_3^-$  has been considered to be biologically unnecessary or a potentially harmful component of the food and water supply, if consumed in excess.<sup>4</sup> Consequently, guidelines for the maximum acceptable value in drinking water,<sup>5</sup> food additive permissions, and acceptable daily intake values<sup>4</sup> have been developed.

Dietary assessment involves the collection of information on foods and beverages consumed over a specified time, which are then coded and processed to compute intakes of energy, nutrients and other dietary constituents using food composition (i.e., 'reference') tables.<sup>6</sup> However, values for NO<sub>3</sub><sup>-</sup> compounds in foodstuffs are not included in national food composition tables.<sup>7</sup> Several  $NO_3^-$  intake studies have relied upon smaller databases or have only included dietary NO<sub>3</sub><sup>-</sup> intake estimates from food sources (i.e., excluding beverages) or vegetables only. In 2018, Babateen et al.<sup>8</sup> performed a systematic review of the available literature to provide an evidence-based evaluation of the methods used to assess NO<sub>3</sub><sup>-</sup> intake, and to assess usual NO<sub>3</sub><sup>-</sup> intake in both healthy and clinical human populations. The review included data from > 3 million participants across 15 countries and reported estimates of the median daily nitrate consumption from individual studies. Babateen et al.<sup>8</sup> observed high heterogeneity in both the types of dietary assessment methods used to record dietary intakes, as well as in the food composition tables/ databases used for converting the dietary intake measures to an estimate of nitrate intake.

There is also a lack of consensus regarding a reference method for assessing dietary NO<sub>3</sub><sup>-</sup>, which may explain differences in NO<sub>3</sub><sup>-</sup> intake reported between studies.<sup>9</sup> Most studies in the review by Babateen *et al.*<sup>8</sup> used food frequency questionnaires (FFQs) (n = 43) to assess dietary intake, one study adopted the use of 24-h food recalls (n = 1) and the others used a combination of both (n = 2). Dietary records (n = 3) and diet history (n = 3) were also used, and one study used a 48-h recall.

There is a growing body of evidence suggesting that high intakes of nitrate-rich food sources, particularly green leafy vegetables, have been associated with improved cardiovascular and metabolic health,<sup>10-17</sup> and improved exercise performance.<sup>14,15,18</sup> However, the ability to measure the association of dietary NO3<sup>-</sup> intake on health and exercise performance depends on having reliable reference methods and dietary assessment tools to assess dietary NO<sub>3</sub><sup>-</sup> intake.<sup>19</sup> The concentration of  $NO_3^-$  in foodstuffs is influenced by a number of factors such as: geographical location, season, growing method, processing factors and the analytical method used, and thus varies considerably both within and between plant species.<sup>20</sup> For example, washing, peeling, cooking (e.g., boiling) and/or pickling have been shown to reduce the nitrate content of vegetables by up to 75% (61%-64%) which is often not considered in dietary assessment. van den Brandt et al.<sup>21</sup> demonstrated that a FFQ could be a useful assessment tool for estimating NO<sub>3</sub><sup>-</sup> intake, used in conjunction with a reference database. Of the 55 studies included in the review by Babateen et al.,<sup>8</sup> only six reported the use of an objective measurement (i.e., plasma, urine or saliva) to estimate dietary nitrate intakes while other studies used various food composition databases. Consequently, the accuracy of published estimates of nitrate intake remains uncertain.

Subsequent to the review by Babateen *et al.*<sup>8</sup> in 2018, a comprehensive  $NO_3^-$  reference database has been developed [McMahon NF, Brooker PG, Pavey TG and Leveritt MD, unpublished data]. Therefore, the present study aimed to: (1) develop a short-term (7-day) FFQ to estimate dietary  $NO_3^-$  intake; (2) estimate the average daily dietary nitrate intake in a sample of healthy adults, using three dietary assessment tools (i) three 24-h dietary recalls; (ii) a short-term (7-day) FFQ; and (iii) a biomarker (urinary nitrate), in conjunction with the newly developed  $NO_3^-$  reference database; and (3) test the validity of a purposefully developed FFQ to estimate  $NO_3^-$  intake.

# **METHODS**

Ethics approval was obtained from the University of Queensland's Human Research Ethics Committee (HMS16/1210R1).

## **Participants and recruitment**

Healthy, active ( $\geq 150$  min week<sup>-1</sup> of moderate to vigorous physical activity) adults between the ages of 18 and 54 years were recruited from the local community and a large metropolitan university via electronic media, print advertising and snowball sampling. Individuals were



excluded from the study based on the following criteria: (1) history of clinical illness or a disease such as cancer; diabetes; a history of symptomatic cardiovascular or peripheral vascular disease; chronic kidney disease; recent history of psychiatric illness; (2) currently prescribed a diuretic; (3) have smoked cigarettes or quit smoking in the last 3 months; (4) body mass index < 18.5 kg m<sup>-2</sup> or > 34.9 kg m<sup>-2</sup>; (5) insufficiently active (<150 min week<sup>-1</sup> of moderate to vigorous physical activity); (6) significant weight loss or gain within the previous 6 months (>6% of body weight); (7) use of

antihypertensive medication; (8) unable to read or speak English; and (9) pregnant or lactating.

# Procedures

An overview of the trial design is shown in Figure 1. Prior to enrolment, potential participants were asked to complete a modified version of the Active Australia Survey,<sup>22</sup> along with a series of questions relating to the inclusion and exclusion criteria to confirm eligibility.



FIGURE 1 Participant trial schedule. ASA24, Automated Self-Administered 24-h; FFQ, food frequency questionnaire

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The Active Australia Survey has demonstrated moderate agreement with other self-report measures of physical activity (Cohen's  $\kappa$  of 0.52).<sup>23</sup> Eligible participants were invited to attend the laboratory for an initial face-to-face session. Participants were instructed to avoid caffeine, alcohol, exercise and smoking in the 12 h prior to their visit to the laboratory at the University of Queensland. During this session, participants were provided with an overview of the study, had an opportunity to ask questions about the study protocol and procedures, and provide informed consent. Enrolled participants were familiarised with the Automated Self-Administered 24-h (ASA24) Dietary Assessment Tool and 24-h urine collection procedure (described below). Participants were asked to maintain their usual level of physical activity and to avoid the use of antibacterial mouthwash throughout the study period.

# Anthropometry

Standing height was measured using a wall-mounted stadiometer (model 217-172-1009; Seca) and body mass was measured using a set of electronic stand-on scales (A&D Mercury Load Cell Digitizer; A&D Weighing), in accordance with the International Society for the Advancement of Kinanthropometry method<sup>24</sup> and recorded to the nearest 0.1 cm and 0.01 kg, respectively.

# Blood pressure

Resting blood pressure (BP) was measured using an aneroid sphygmomanometer (single-hand dual-tube 883; Prestige Medical) after participants rested in a quiet room for 10 min. Measurements were taken twice with a 10-min break between each measurement. Mean arterial pressure (MAP) was calculated using<sup>25</sup>:

MAP = diastolic BP + (0.333 [systolic BP - diastolic BP]).

## Dietary assessment

#### 24-h dietary recalls

Participants were asked to recall all foods and beverages consumed during the previous 24-h (midnight-midnight) using the ASA24 system. Participants were also prompted to provide a brief description of time, cooking/preparation methods, brand names, and recipes. To account for day-today variation, participants completed three 24-h dietary recalls (two weekdays and one weekend day) over a 1-week period. A trained nutritionist reviewed the records for completeness; follow-up phone calls were made if clarification was needed or if the information was inadequate. The ASA24 system requires a certain level of skill; therefor, participants were provided with an instruction booklet of how to record their food and beverage intake using the ASA24 system during their first appointment. Compared to interviewer-assisted recalls, the ASA24 method is less time and resource intensive and demonstrates similar levels of completeness (80% vs. 83%, respectively).<sup>26</sup>

#### FFQ

The FFQ (see Supporting information, Doc. S1) was purposefully designed to capture participant's habitual  $NO_3^{-}$  food and beverage intake over the previous 7 days. Participants reported their frequency of consumption of particular foods across a period of 1 week via a FFQ (online). Sample responses ranged from 'never' to '6 per day.' Portion sizes were set to '1 serve = 1 metric cup' to avoid confusion. Participants were provided with verbal instructions regarding how to complete the FFQ, and written instructions at the start of the questionnaire. The quantitative FFQ was made up of food and drink items gathered into the following categories: (1) vegetables; (2) legumes; (3) herbs; (4) wild plants/herbs; (5) fruits; (6) processed meats; (7) other; (8) juice; (9) supplements; and (10) drinking water (tap and bottled). Participants were also instructed to report if the food item was thermally processed (steamed, boiled, microwaved, fried or cooked - non-specific) because of the resultant variation in NO<sub>3</sub> content.<sup>27</sup> The FFQ was completed online during or directly after the final lab-visit to avoid influencing participant's habitual dietary intake, by educating participants about dietary sources of NO<sub>3</sub><sup>-</sup>. Seven days was chosen in favour over a longer-term FFQ because this has previously been shown to be highly correlated with the daily mean intake taken from three 24-h recalls.<sup>28</sup> Additionally, a 1-week washout period is the most common duration for dietary NO<sub>3</sub><sup>-</sup> studies measure performance and health outcomes.<sup>29</sup>

Prior to the present study, feedback was sought from a sample of 10 allied health professionals. Face and content validity, feedback on content, length, and language incorporated in the questionnaire and comments were integrated into the design process. After incorporating relevant feedback, the final version of the FFQ was assessed for its test-retest reliability, separated by 24-h (n = 20). The level of agreement between reviewers evaluating the reliability of the questionnaire was assessed using Cohen's  $\kappa$  statistics using The  $\kappa$  values were interpreted using the ranges suggested by Landis and Koch<sup>30</sup> and was considered 'almost perfect' (0.89).

# Estimating dietary nitrate intakes

Values for  $NO_3^-$  compounds in foodstuffs are not included in national food composition tables, therefore intakes were estimated from a recentlyy developed  $NO_3^-$ 

reference database, [McMahon NF, Brooker PG, Pavey TG and Leveritt MD, unpublished data] which is currently the most comprehensive  $NO_3^{-}$  database available for use. The database contains 5024 records for  $NO_3^-$  values (mg per 100 g) of food and beverages spanning 64 countries, established from a systematic literature search including data from original research studies and previously developed databases. Therefore, the most appropriate values were chosen for each item based on a ranking system, giving preference to: (1) Australia from 1990 to present; (2) Australia from 1960 to 1989; (3) countries with predominately Western Diets (US, Canada, UK and other European countries, and New Zealand from 1990 to present; 4) countries with predominately Western Diets (US, Canada, UK and other European countries, and New Zealand from 1960 to 1989; (5) countries with predominately non-Western diets from 1990 to present; and (6) countries with predominately non-Western diets from 1960 to 1989. The cut-off dates were chosen to account for changes in laboratory methods, food preservation techniques and manufacturing technologies [i.e., the addition of ascorbate during meat processing (added to reduce the formation of nitrosamines)], and legislation regulating the amounts of NO<sub>3</sub><sup>-</sup> used in the curing process created significant reductions in food and beverages.<sup>31,32</sup>

Nitrate values were available for most commonly consumed food and beverages. Table 1 shows the number of items included in the database, sorted into 12 subcategories. Nitrate intake was estimated by multiplying the food or beverage item consumed (g day<sup>-1</sup>) by the weighted mean value of that item identified using the multistep process described above. If a  $NO_3^-$  value was unattainable a value of 0 mg g<sup>-1</sup> was assigned to the food

 TABLE 1
 The number of items included in the nitrate reference database, grouped by food and beverage subcategories

Subcategory	n
Alcohols	20
Baby	288
Dairy	223
Fats, oils, nuts, spices and sugars	143
Fruit products	185
Grain products	77
Legumes (beans, peas, lentils)	229
Other	3
Processed meats	213
Protein foods (of animal origin)	311
Vegetables and herbs	3191
Water and other beverages	141
Total	5024

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or beverage item. The database includes both raw and thermally-processed samples; where participants reported they had consumed cooked foods (e.g., boiled broccoli), the most appropriate value from the database was chosen. Weighted mean was selected as some mean values were adversely affected by extreme values.

## 24-h recall

To estimate dietary  $NO_3^-$  intake across the three recalled days, the  $NO_3^-$  content of all individual foods reported in the ASA24 system was calculated, using values from the database.<sup>33</sup> In the case of multicomponent foods (e.g., pizza, juices, salad mix, soup and baby-food mixtures) nutrient values were determined by calculating the  $NO_3^-$  of all ingredients contained in the recipe list or, in the case of commercial products, by looking and the ingredients list or using the recipe reproduction. Total  $NO_3^-$  (mg day<sup>-1</sup>) were determined by calculating the sum of daily  $NO_3^-$  values and the average was calculated across the 3 days.

# FFQ

To estimate dietary  $NO_3^-$  intake from the FFQ, first, food and beverage intake data for each participant (measured in number of servings, where 1 serve = 1metric cup) were copied into Excel, version 2018 (Microsoft Corp.) and converted to intakes in grams. Cup weights were calculated for each food using values from the United States Department of Agriculture Food Data Central Database,<sup>34</sup> based on a best match (including whether the food was cooked or raw). For example, one cup of broccoli (raw) was recorded as 76 g and one cup of broccoli (boiled, microwaved or streamed) was recorded as 156 g. Next, the NO<sub>3</sub><sup>-</sup> content was calculated for each item, using values from the reference database (described above), and all items were summed to give a total weekly intake. Finally, the weekly intake of dietary NO<sub>3</sub><sup>-</sup> was divided by seven to calculate an average daily intake for comparability to the estimates from the 24-h recall data.

# Urinary nitrate

Urinary NO<sub>3</sub><sup>-</sup> was chosen as a NO<sub>3</sub><sup>-</sup> biomarker because 65%-70% of ingested NO<sub>3</sub><sup>-</sup> is excreted in the urine after a period of 24 h.<sup>35</sup> The urine collection was undertaken following standard procedures.<sup>36</sup> The collection began at the participant's second urine sample of the morning and concluded after their first urine sample collection on the following morning.

Participants were provided with a urine specimen container (hat), designed to be placed under the toilet seat to collect and measure whole urine samples. For each void over a 24-h period, participants were asked to record the total volume of each void (in millilitres) and collect a small sample (poured from the urinal hat) into a 70-ml sterile urine container without preservative, after the first urine void of the morning. Participants were asked to record the exact time of each collection (hh:mm) IHND

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in a small booklet provided at the commencement of the study. To preserve the sample for future analyses, participants were given clear instructions regarding storage and transport processes; samples were to be stored in a refrigerator (2–8°C) immediately after collection, and were not to be placed in direct sunlight. Participants were provided with deionised water to clean the urinal hat after each collection and left to air dry.

The 24-h urine collection was completed on the same day as the final ASA24 recall. Participants were asked to report whether the 24-h collection period was completed as planned, whether samples were missed/spilt (and if so, how many) and whether their 24-h collection period mirrored the amount/frequency of a typical day. If participants did not comply to the collection protocol, or reported missing samples, the 24-h urine sample was not included in the analysis. Participants returned their urine samples to the laboratory where they were aliquoted into 1-ml portions and stored at  $-80^{\circ}$ C for subsequent analysis.

The chemiluminescence method has shown to offer the highest analytical consistency in terms of sensitivity and precision and is the generally accepted 'gold standard,<sup>37</sup> and was used to measure urinary NO<sub>3</sub><sup>-</sup> concentrations in the present study. To prepare the samples for analysis, the frozen urine aliquots were heated at approximately 90°C in an acidic environment (1 M hydrochloric acid) in the presence of vanadium (III) chloride to catalyse the reduction of NO<sub>3</sub><sup>-</sup> to nitrite and then to nitric oxide. Nitric oxide levels were measured with a chemiluminescent analyser in accordance with the manufacturer's recommendations (Sievers NOA 280i; GE Analytical Instruments). Samples were analysed in duplicate and compared with a standard curve created using dilutions of NO<sub>3</sub><sup>-</sup>. No samples were above or below the limit of detection for the NO analyser. Duplicate urine measurements had a mean coefficient of variation of 1.17%.

# Statistical analysis

A sample size of approximately 50 to 100 is recommended for FFQ validation studies<sup>38</sup> and was the target for the present study. Normality of distribution of data was assessed by the Kolmogorov–Smirnov test and by visual inspection of histograms for skew and kurtosis. The raw data for the urinary  $NO_3^-$  totals, 24-h recall and FFQ were not normally distributed but were positively skewed, as generally found with nutrient intake data.<sup>39</sup> Logarithmic transformations were used, when appropriate, to normalise the data. Pearson correlation coefficients were used to evaluate the consistency of dietary patterns derived from dietary data collected with the three 24-h recalls. Spearman's rho correlation coefficients were used on the unadjusted data to assess the linear relationship between urinary  $NO_3^-$  excretion and  $NO_3^-$  intake calculated from the 24-h recall and FFQ (n = 50). Bland–Altman analyses of the raw NO<sub>3</sub><sup>-</sup> intake data for the 24-h recall and the FFQ were used to evaluate the limits of agreement and the presence or absence of systematic bias.<sup>40</sup> A paired *t* test was used to evaluate the presence of fixed bias between methods. The values of the correlation coefficient were interpreted using the ranges suggested by Rowntree<sup>41</sup> of <0.10–0.20 = very weak, 0.20–0.40 = low, 0.40–0.70 = moderate, 0.70–0.90 = high and 0.90–1.00 = very high. Statistical analyses were performed using SPSS, version 25 (IBM Corp.). p < 0.05(two-sided) was considered statistically significant.

# RESULTS

Fifty-nine participants were enrolled in the study, of whom 50 (n = 32 male) completed the study. Three individuals withdrew after the first study visit, and six failed to return urine samples. The baseline characteristics of the sample of participants included in the final analyses are presented in Table 2.

Estimates of nitrate intakes from the 24-h recalls ranged between 4.4 and 667.0 mg day<sup>-1</sup>. Pearson correlations comparing daily intakes of nitrate estimated from the three 24-h recalls are listed in Table 3. Pearson correlation coefficients were statistically significant between the three recalled days (day 1 vs. day 2: r = 0.394, p = 0.005; day 1 vs. day 3: r = 0.573, p < 0.001; and day 2 vs. day 3: r = 0.578, p < 0.001), suggesting that estimates of dietary nitrate were similar between the three recalled days.

The mean NO<sub>3</sub><sup>-</sup> intake estimated from the three 24-h recalls was  $130.94 \pm 99.44 \text{ mg} \text{ day}^{-1}$  and  $180.62 \pm 214.95 \text{ mg} \text{ day}^{-1}$  from the FFQ (Table 4). There was a moderate positive correlation between the FFQ and 24-h recall data (r = 0.736,  $\rho < 0.001$ ) (Figure 2). Bland–Altman analysis and the paired sample *t* test revealed a significant fixed bias with the FFQ measuring 49.68 mg higher mean NO<sub>3</sub><sup>-</sup> intake (mg day<sup>-1</sup>) (95% confidence interval =  $5.08-94.28 \text{ mg} \text{ day}^{-1}$ ,  $\rho < 0.015$ ) than the 24-h recall.

<b>IADLE 2</b> Describe characteristics of study participants $(n - 3)$	ГΑ	BLE	2	Baseline	characteristics	of study	participants	(n = 50)
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	Mean (SD)	Interquartile range
Age (years)	25 (8.2)	20–28
Height (cm)	174.33 (8.1)	170.1–179.1
Weight (kg)	69.82 (10.4)	63.7–76.8
Body mass index (kg m <sup>-2</sup> )	22.88 (2.3)	21.4–24.2
Systolic blood pressure	117.98 (10.7)	110–123
Diastolic blood pressure	77.26 (7.9)	73-80.1
Mean arterial pressure	90.83 (8.3)	85.8–94.6

**TABLE 3** Daily nitrate (mg day<sup>-1</sup>) estimates from multiple 24-h recalls

	Nitrate estimates (mg day <sup>-1</sup> )			Pearson correlations					
				Day 1 vs.	Day 1 vs.	Day 2 vs.			
	Day 1	Day 2	Day 3	day 2	day 3	day 3			
Mean	136.13	114.50	141.51	0.394	0.573	0.578			
Range	4.4-667.0	5.9-444.5	8.5-444.4						

The overall difference between the two dietary assessment tools was 49.68 mg day<sup>-1</sup> of NO<sub>3</sub><sup>-</sup> (higher average intake estimated from the FFQ). In terms of relative contribution, the greatest discrepancy between the 24-h recall and FFQ came from cooked herbs (0.4% vs. 7.7%) and uncooked herbs (0.2% vs. 4.3%) and other cooked vegetables (0.4% vs. 7.7%), respectively. A further discrepancy of 43.17 mg day<sup>-1</sup> of NO<sub>3</sub><sup>-1</sup> was recorded between the tools for food and beverage items not listed in the FFQ, but reportedly consumed during the 24-h recall. These items included high NO<sub>3</sub><sup>-</sup> sources such as vegetable combinations (soup, salads and other mixed vegetable items) and low NO3<sup>-</sup> sources such as coffee, beef, strawberries, rice and bread that, when consumed in large quantities, contributed to the difference in the total NO<sub>3</sub><sup>-</sup> intake. If these had been captured in the FFQ, the discrepancy between the two tools would have been close to  $100 \text{ mg day}^{-1}$  (24-h recall, 130.94 mg day<sup>-1</sup> vs. FFQ,  $223.79 \text{ mg day}^{-1}$ ;  $180.62 + 43.17 \text{ mg day}^{-1}$ <sup>1</sup>).

The mean total urinary NO3<sup>-</sup> excretion was  $1974.79 \pm 1168.92 \,\mu\text{mol}$  day<sup>-1</sup> (917.9 ± 691  $\mu\text{mol}$  L<sup>-1</sup>). There was a moderate positive correlation between urinary NO<sub>3</sub><sup>-</sup> excretion and NO<sub>3</sub><sup>-</sup> estimated from the FFQ (r = 0.579,  $\rho < 0.001$ ) and a strong positive correlation between urinary NO<sub>3</sub><sup>-</sup> excretion and NO<sub>3</sub><sup>-</sup> estimated from the 24-h recall (r = 0.632,  $\rho < 0.001$ ).

# DISCUSSION

The purpose of the present study was two-fold: (1) to estimate the average daily dietary nitrate intake in a sample of healthy adults, using three dietary assessment tools, in conjunction with a nitrate reference database, and (2) to test the validity of a purposefully developed FFQ to estimate nitrate intake. Daily dietary nitrate intake estimates were 130.94 mg (average of three 24-h recalls) and 180.62 mg (FFQ). Despite the variation between the two dietary assessment methods, there was a moderate positive correlation (r = 0.736,  $\rho < 0.001$ ), suggesting reasonable comparability between the 24-h diet recalls and FFQ in estimating dietary nitrate intake. The mean urinary  $NO_3^-$  excretion was 1974.79 µmol day<sup>-1</sup> (or 917.9 µmol L<sup>-1</sup>). There was a moderate positive correlation between urinary NO3<sup>-</sup> excretion and NO3<sup>-</sup> estimated from the FFQ (r = 0.579,  $\rho < 0.001$ ) and a

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BOA The Associ strong positive correlation between urinary NO<sub>3</sub><sup>-</sup> excretion and NO<sub>3</sub><sup>-</sup> estimated from the 24-h recall (r = 0.632,  $\rho < 0.001$ ). Irrespective of the dietary assessment method used, estimated average nitrate intakes were below the acceptable daily intake of 3.7 mg NO<sub>3</sub><sup>-</sup> per kg body weight (approximately 250 mg day<sup>-1</sup> for an adult weighing 70 kg) established by the World Health Organization.<sup>42</sup> The reported nitrate values in this study are similar to other published estimates.<sup>8,43</sup> For example, Jackson et al.<sup>43</sup> estimated dietary nitrate intakes were, on average, 65-70 mg day<sup>-1</sup> in a sample of 8161 representative Australians from the Australian Longitudinal Study on Women's Health from 2001 and 2013. From their

healthy and clinical populations, respectively.<sup>8</sup> Vegetables and herbs were the largest contributor to  $NO_3^{-}$  in the diet. Based on the average of the three 24-h recalls, vegetables and herbs accounted for 62% of daily  $NO_3^-$  intake (approximately 80 mg day<sup>-1</sup>). Estimates from the FFQ showed 93% of daily NO<sub>3</sub><sup>-</sup> intake from vegetables and herbs (approximately  $169 \text{ mg } \text{day}^{-1}$ ). These findings are similar to other estimates in the literature which report approximately 60%-80% of the total daily  $NO_3^{-1}$  intake comes from vegetables.<sup>2,8,31,43–45</sup> Similar to consumption patterns published in other studies, there was a higher proportion of vegetables consumed in their cooked form (24-h recall, 61%; FFQ, 57%) versus in their raw form (24-h recall, 39%; FFQ, 43%).

systematic review that included data from > 3 million participants across 15 countries, Babateen et al.8 estimated

median daily nitrate intake was 108 and 110 mg/dav for

There was a moderate positive correlation between the 24-h recalls and FFQ in this study, but estimates of  $NO_3^{-1}$  intake differed by approximately 100 mg day<sup>-1</sup>. There was a stronger association between estimates from the 24-h recalls and urinary  $NO_3^-$  excretion than the FFQ, suggesting intakes of NO<sub>3</sub><sup>-</sup>-rich foods may have been overestimated in the FFQ. All dietary assessment tools are susceptible to bias and have the potential for error. Misreporting is a common challenge in dietary assessment, regardless of the assessment tool, likely because of a variety of factors. For example, systematic bias may be introduced where the assessment tool does not capture specific aspects of the local diet (such as foods indigenous to certain population groups)<sup>26</sup>. Underreporting of habitual dietary intake is also welldocumented in research studies, which may be a result of social desirability, opportunistic bias or memory.<sup>6,46</sup> However, over-reporting is more common in FFQs, dependent on the number of food categories.<sup>6,47,48</sup>

The customised FFQ used in the present study only included foods and beverages with a moderate to high  $NO_3^{-}$  level, whereas the 24-h recall included  $NO_3^{-}$  values from every food and beverage consumed. Additionally, multiple 24-h recall administrations were used to account for day-to-day variation, however this is only an average - JHND

TABLE 4	Comparison	between food a	nd beverage	items of	contributing	to total	dietary	nitrate	intake	from 1	the food	frequency	questionnair	ſе
(FFQ) and the	e 24-h recall													

	FFQ		24-h recall	
Food items	mg day <sup>-1</sup>	Percent of daily intake	mg day <sup>-1</sup>	Percent of daily intake
Uncooked dark green vegetables (such as broccoli, rocket, silverbeet, spinach, kale or pak choy)?	28.21	15.6	24.18	18.5
Cooked dark green vegetables (such as broccoli, rocket, silverbeet, spinach, kale or pak choy)?	29.12	16.1	23.64	18.1
Uncooked cabbage (such as brussels sprouts, Chinese cabbage, coleslaw, savoy or sauerkraut)?	0.49	0.3	0.80	0.6
Cooked cabbage (such as brussels sprouts, Chinese cabbage, coleslaw, savoy or sauerkraut)?	1.54	0.8	1.55	1.2
Uncooked lettuce (such as cos, iceberg, oak-leaf or mixed)?	12.95	7.2	8.42	6.4
Uncooked red and/or orange vegetable (such as carrot, pumpkin, chili pepper, capsicum, sweet potato or tomato)?	3.85	2.1	0.80	0.6
Cooked red and/or orange vegetable (such as carrot, pumpkin, chili pepper, capsicum, sweet potato or tomato)?	2.52	1.4	1.71	1.3
Uncooked radish (such as black, Japanese, radish sprouts, red, sweet or white)?	2.52	1.4	0.00	0.0
Cooked radish (such as black, Japanese, radish sprouts, red, sweet or white)?	0.77	0.4	0.43	0.3
Other uncooked root or tuber vegetables (such as artichoke, beetroot, celeriac, potato, radish, swede or turnip)?	17.29	9.6	2.60	2.0
Other cooked root or tuber vegetables (such as artichoke, beetroot, celeriac, potato, radish, swede or turnip)?	11.76	6.5	8.86	6.8
Uncooked stem vegetable (such as bamboo shoots, celery, fennel, rhubarb or leek)?	2.10	1.1	1.02	0.8
Cooked stem vegetable (such as bamboo shoots, celery, fennel, rhubarb or leek)?	5.60	3.1	0.87	0.7
Other uncooked vegetable (such as cauliflower, cucumber, eggplant, garlic, mushroom, onion, squash or zucchini)?	5.18	2.9	2.38	1.8
Other cooked vegetable (such as cauliflower, cucumber, eggplant, garlic, mushroom, onion, squash or zucchini)?	13.93	7.7	0.49	0.4
Uncooked legumes (such as broad, French, and green/string beans, and bean sprouts)?	4.41	2.4	0.18	0.1
Cooked legumes (such as broad, French, and green/string beans, and bean sprouts)?	7.28	4.0	1.39	1.1
Uncooked herb (such as basil, chives, coriander, dill, ginger or parsley)?	7.84	4.3	0.20	0.2
Cooked herb (such as basil, chives, coriander, dill, ginger or parsley)?	11.48	6.4	0.00	0.0
Uncooked bananas?	4.13	2.3	2.86	2.2
Cooked bananas?	0.07	0.1	0.00	0.0
Uncooked exotic fruit (such as jackfruit, towel, bitter, round or wax gourd [winter melon])?	0.21	0.1	0.00	0.0
Cooked exotic fruit (such as jackfruit, towel, bitter, round or wax gourd [winter melon])?	0.28	0.2	0.00	0.0
Processed meat products (bacon, sausages, pâté or luncheon meats)?	3.01	1.7	0.84	0.6
Potato crisps, gyoza or quiche (vegetable)?	3.85	2.1	4.54	3.5
Vegetable juice (homemade or commercial)?	0.14	0.1	0.00	0.0
Nitrate supplements	0.00	0.0	0.00	0.0
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### TABLE 4 (Continued)

	FFQ		24-h recall	
Food items	mg day <sup>-1</sup>	Percent of daily intake	mg day <sup>-1</sup>	Percent of daily intake
Alcohol			1.52	1.2
Other leafy			1.60	1.2
Other-combination foods such as sushi, vegetable soups (canned), pizza, spaghetti, rice dishes, mixed sauces etc. (may include nitrate-rich foods, but are not captured in the FFQ)			21.80	16.6
Water			1.89	1.4
Other-low $NO_3^-$ sources such as coffee, beef, strawberries, rice, and bread (not captured in the FFQ)			16.36	12.5
Total	180.62	100	130.94	100



**FIGURE 2** Scatter plot of mean nitrate intake (mg day<sup>-1</sup>) measured by a food frequency questionnaire (FFQ) and 24-h recall showing Spearman's correlation coefficient (n = 50)

and days with large  $NO_3^-$  intake amounts may have contributed to the discrepancy between dietary assessment methods. Despite the current FFQ being a useful ranking tool because of the quickness, ease of administration and cost-effectiveness, for greater dietary  $NO_3^$ intake accuracy, the findings from the present study suggest multiple administrations of 24-h recall to be the more reliable method. Blekkenhorst *et al.*<sup>20</sup> reported similar findings in their study which aimed to assess the correlations of vegetable  $NO_3^-$  intake between 24-h food recalls and a short-term (4-week) and long-term (12-month) FFQ. In their sample of 41 adults, the mean  $NO_3^-$  intake estimated from the 24-h recall and 12-month FFQ was  $89.3 \pm 64.7 \text{ mg day}^{-1}$  and  $71.9 \pm 33.9 \text{ mg}$  day<sup>-1</sup>, respectively. The researchers reported a moderate positive correlation between NO<sub>3</sub><sup>-1</sup> intakes estimated from the 24-h recalls and 12-month FFQ.

Regardless of the tool used, accurate assessment of dietary intake is always challenging and complex due to intra-individual variability (i.e., the day-to-day variance in foods people eat) and inter-individual variability (such as differences between populations and the types of foods consumed).<sup>47,49</sup> This research adds a valuable contribution to the existing literature. Dietary NO<sub>3</sub><sup>-</sup> was estimated using the most comprehensive and up-to-date reference database available, [McMahon NF, Brooker PG, Pavey TG and Leveritt MD, unpublished data] and is one of only

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seven studies to have assessed dietary  $NO_3^-$  intake in humans using a biomarker, and the only study that has collected samples continuously for more than 12 h.<sup>8</sup>

Despite the strengths of this research, a number of limitations must be acknowledged. The daily NO<sub>3</sub><sup>-</sup> intakes estimated from the FFQ and 24-h recalls differed by approximately 100 mg. By design, the customised FFQ used in this study only included foods and beverages with a  $NO_3^-$  moderate to high level (> 10 mg per 100 g) whereas the 24-h recalls included  $NO_3^{-}$  values from every food and beverage reportedly consumed. There is currently no acceptable biological indicator to assess nitrate intake. Urinary nitrate may provide an indication of dietary nitrate intake, however, urinary nitrate levels are affected by the L-arginine-NO synthase pathway, and the high nitrate excretion rate (approximately 75%) and therefore do not provide a robust indicator of longer-term nitrate intake.<sup>20,50</sup> The discrepancy in the measurement of nitrate intake between the FFQ and 24-h recalls should also be acknowledged in the context of health outcomes. This is roughly the equivalent of more than one cup of leafy green vegetables. In recognition of the dose-response relationship between fruit and vegetable intake and mortality, the FFQ should not be used to draw conclusions about absolute intakes.<sup>51</sup>

### CONCLUSIONS

There are a number of studies which highlight the benefit of consuming a nitrate-rich diet.<sup>4,43,52</sup> Despite this, optimal NO<sub>3</sub><sup>-</sup> intake strategies are unclear. Habitual  $NO_3^{-}$  intake is a factor that has the potential for discovery and development of health interventions designed to positively impact cardiovascular, metabolic and cognitive health across the lifespan. However, the ability to assess nitrate intakes depends on having suitable reference methods to estimate the concentrations of nitrate in the food supply, coupled with valid and reliable dietary assessment tools. There was a moderate positive correlation between the 24-h recalls and FFQ in this study, but there was a sizeable difference in NO<sub>3</sub><sup>-</sup> intake (105.14 mg). There was a stronger association between estimates from the 24-h recalls and urinary NO<sub>3</sub><sup>-</sup> excretion than the FFQ, suggesting intakes of NO<sub>3</sub><sup>-</sup>-rich foods may be underestimated in the FFQ. This discrepancy is likely because of limitations in the dietary assessment methods. Based on these findings, at an individual level, dietary recalls or records may be more accurate in estimating intake of NO<sub>3</sub><sup>-</sup>. Conclusions cannot be drawn about absolute nitrate intakes measured from the FFQ. However, given the lower cost and time needed for administration relative to recalls, the FFQ has merit for estimating NO<sub>3</sub><sup>-</sup> intakes in health interventions, dietary surveys and surveillance programs such as large cohort studies. Future research should consider

methods to improve the FFQ so it may be used as a tool to provide more reliable estimates about absolute nitrate intakes and aid researchers in drawing conclusions about diet–disease relationships.

### AUTHOR CONTRIBUTIONS

Nicholas F. McMahon conceptualised the study. Nicholas F. McMahon and Michael D. Leveritt developed the study design. Nicholas F. McMahon was responsible for data collection and analysis, and contributed to preparing the manuscript. Paige G. Brooker assisted with data collection and analysis, and was responsible for drafting and preparing the manuscript. Stefan Kadach contributed to data analysis. Toby G. Pavey provided statistical advice. All authors contributed to the interpretation of the results and critically reviewed the manuscript.

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### **CONFLICTS OF INTEREST**

The authors declare no conflicts of interest.

### ETHICAL STATEMENT

Ethics approval was obtained from the University of Queensland's Human Research Ethics Committee (HMS16/1210R1).

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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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# JUNE OF HUMAN NUTRITION AND DIELECTORY

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The Association of UK Dietitians

## Journal of Human Nutrition and Dietetics

The Official Journal of the British Dietetic Association

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### CLINICAL PRACTICE



# Nutritional problems of patients with COVID-19 receiving dietetic treatment in primary care

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### Abstract

**Background:** The nutritional problems of patients who are hospitalised for COVID-19 are becoming increasingly clear. However, a large group of patients have never been hospitalised and also appear to experience persistent nutritional problems. The present study describes the nutritional status, risk of sarcopaenia and nutrition-related complaints of patients recovering from COVID-19 receiving dietetic treatment in primary care.

**Methods:** In this retrospective observational study, data were collected during dietetic treatment by a primary care dietitian between April and December 2020. Both patients who had and had not been admitted to the hospital were included at their first visit to a primary care dietitian. Data on nutritional status, risk of sarcopaenia and nutrition-related complaints were collected longitudinally.

**Results:** Data from 246 patients with COVID-19 were collected. Mean  $\pm$  SD age was 57  $\pm$  16 years and 61% of the patient population was female. At first consultation, two thirds of patients were classified as overweight or obese (body mass index >25 kg m<sup>-2</sup>). The majority had experienced unintentional weight loss because of COVID-19. Additionally, 55% of hospitalised and 34% of non-hospitalised patients had a high risk of sarcopaenia. Most commonly reported nutrition-related complaints were decreased appetite, shortness of breath, changed or loss of taste and feeling of being full. Nutrition-related complaints decreased after the first consultation, but remained present over time.

**Conclusions:** In conclusion, weight changes, risk of sarcopaenia and nutritionrelated complaints were prevalent in patients with COVID-19, treated by a primary care dietitian. Nutrition-related complaints improved over time, but remained prevalent until several months after infection.

### **KEYWORDS**

COVID-19, dietitian, nutrition-related complaints, nutritional status, primary care, sarcopaenia

### Key points

- Weight changes, risk of sarcopaenia and nutrition-related complaints were prevalent in patients with COVID-19 treated by a primary care dietitian.
- Most commonly reported nutrition-related complaints were decreased appetite, shortness of breath, changed or loss of taste and feeling of being full.

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- Nutrition-related complaints improved over time, but remained prevalent until several months after infection.
- The risk of a poor nutritional status and high risk of sarcopaenia should be considered, especially in combination with persistent nutrition-related complaints as a result of COVID-19.

### INTRODUCTION

The recent worldwide COVID-19 pandemic as a result of the Coronavirus SARS-CoV-2 has caused major challenges for healthcare professionals all over the world.<sup>1,2</sup> Symptoms of COVID-19 vary amongst individuals and may range from asymptomatic to severe respiratory failure requiring admission to hospital or even admission to an intensive care unit (ICU).<sup>3–6</sup> After the acute phase, many people experience persistent symptoms until a few weeks to several months after infection.<sup>7-9</sup> In addition to general COVID-19 symptoms, such as fever, fatigue, cough, dyspnoea and nutrition-related complaints, are common in patients recovering from COVID-19.8,10,11 Nutrition-related complaints include loss of taste and smell, loss of appetite, nausea, vomiting or diarrhea, which may lead to reduced food intake and/or decreased nutrient absorption.<sup>12,13</sup> As a consequence, nutritional requirements are often not met, which can result in unintentional weight loss and loss of muscle mass and strength. Additionally, physical inactivity as a result of COVID-19 is a risk factor for loss of muscle mass and strength.<sup>14</sup> Weight loss and loss of muscle mass and strength are common in patients with COVID-19, both in the acute phase and up to several months after infection.<sup>15</sup> Previous studies have shown that COVID-19 is associated with a poor nutritional status, which may result in a high risk of malnutrition<sup>11,16–18</sup> and sarcopaenia.<sup>11,19–21</sup>

Most nutrition studies have focused on hospitalised patients with severe COVID-19. The recently published prospective COVOED study investigated the nutritional status, risk of sarcopaenia and nutrition-related complaints of hospitalised patients with COVID-19.<sup>11</sup> Almost all patients had one or more nutrition-related complaints. The most predominant complaints were decreased appetite, feeling of being full, shortness of breath, changed taste and loss of taste. These nutrition-related complaints persisted 3–5 months after discharge.<sup>11</sup>

Only limited literature has been identified on nutritional problems of patients recovering from COVID-19 in primary care. A recent review advices to pay attention to prolonged nutritional problems in patients based at home.<sup>22</sup> Therefore, this retrospective part of the COV-OED study describes the nutritional status, risk of sarcopaenia and nutrition-related complaints of patients with COVID-19 treated by a primary care dietitian in 2020. Additionally, it describes the duration of treatment and method of performing the dietetic consultation of primary care dietitians treating COVID-19 patients.

### METHODS

### Study design and population

The present study is part of the larger COVOED study, an observational cohort study. We retrospectively collected data from adult patients who received dietetic care for COVID-19 by a primary care dietitian between 27 April and 31 December 2020. Dietetic practices in The Netherlands were approached via email or via the Dutch Dietetic Association, and invited to participate in the study. Patients, in turn, were invited by their treating dietitians and a written informed consent was signed by all participating patients. Patients included in the study were likely to have had the Wuhan-variant of the Coronavirus SARS-CoV-2. Both patients admitted to the hospital and patients never admitted to the hospital were included. Dietitian-reported data were retrieved from the electronic patient files and transferred to Castor Electronic Capture (version: Castor EDC 2020.2, Amsterdam, The Netherlands), a web-based electronic platform.

Patients were entered into the study at their first visit to a primary care dietitian. Data were categorised for each time point, that is at first consultation (study entry), after 1 month, as well as 2, 3 and 4–6 months.

### **Patient characteristics**

The following general items were collected to describe the patient population: age, gender, and hospital admission (yes/ no). For patients who had been admitted to the hospital for COVID-19, data on previous length of hospital stay (LOS), hospital ward and ICU stay, and any support therapy received (i.e., oxygen mask, ventilatory support, tube feeding) were recorded. ICU patients were defined as having been admitted to the ICU at any point in time during hospitalisation. Hospital ward patients were defined as having been hospitalised, but not admitted to ICU. Additionally, data on consistency of oral nutrition and use or oral nutrition supplements were collected.

### Nutritional status

The nutritional status of the patients was assessed by body mass index (BMI) and weight changes before the first consultation with the primary care dietitian. Body weight and height were used to calculate BMI (weight/ IHND

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height<sup>2</sup>). BMI was categorised as described by the World Health Organization (WHO)<sup>23</sup>: underweight BMI 18.5 kg m<sup>-2</sup>, normal weight 18.5–25 kg m<sup>-2</sup>, overweight BMI 25–30 kg m<sup>-2</sup>, obesity BMI 30–40 kg m<sup>-2</sup> and morbid obesity > 40 kg m<sup>-2</sup>. Dietitians were asked to measure body composition with bioelectric impedance analysis.

The risk of sarcopaenia was assessed with the SARC-F questionnaire.<sup>24,25</sup> The SARC-F consists of five items: strength, assistance in walking, rise from a chair, climbing stairs and falls. A total score of 4 or more indicates an increased risk of sarcopaenia.

### Nutrition-related complaints

The following nutrition-related complaints were collected during the dietetic consultations: decreased appetite (anorexia), shortness of breath, nausea, feeling of being full, changed taste, loss of taste (ageusia), difficulty chewing or swallowing and pain in the mouth. Four nutrition-related complaints were added halfway during data collection because these complaints were commonly, but not systematically, reported in the electronic patient files of the primary care dietitians: fatigue, muscle weakness, loss of smell (anosmia) and changed smell. For appetite, a visual analogue scale (1–100) was used.<sup>26</sup> Additionally, dietitians were asked to use the Bristol Stool Chart to assess stool frequency and consistency.<sup>27</sup>

### **Dietetic treatment**

The following items were collected to describe the dietetic treatment in primary care: referring physician, method of performing dietetic consultation, number of consultations, number of hours reimbursed by the health insurance, duration of dietetic treatment and reason for ending dietetic treatment. Additionally, the involvement of a physiotherapist at any point in time during the dietetic treatment was recorded. The method of performing the dietetic consultation was categorised into three categories: completely remotely (by telephone or video call), completely face-to-face (at practice site or via home visit) or blended.

### Statistical analysis

Descriptive analyses were performed to describe the patient population using proportions, mean  $\pm$  SD, and medians with interquartile ranges (IQR), as well as to analyse the nutritional status, risk of sarcopaenia and nutrition-related complaints. Different patient characteristics and nutritional status between hospitalised and non-hospitalised patients were quantified by means of independent samples *t* tests and chi-squared tests. All

data were analysed using SPSS, version 25 (IBM Corp.) p < 0.05 was considered statistically significant.

### RESULTS

### **Patient characteristics**

In total, 246 patients were included in the study (Table 1). Mean  $\pm$  SD age was 57  $\pm$  16 years and 61% of the patient population was female. Forty-three per cent of the patient population had been hospitalised for COVID-19, of which 51% of the patients had been admitted to the ICU. Hospitalised patients were significantly older (64  $\pm$  13 years) compared to nonhospitalised patients (52  $\pm$  16 years). The hospitalised group consisted of more men (58%), whereas the nonhospitalised group consisted of significantly more women (76%). Additional data on hospital admitted patients is provided in the Supporting information (Table 1).

### Nutritional status

Data on the nutritional status of included patients with COVID-19 at the first dietetic consultation by a primary care dietitian is described in Table 1. Mean ± SD BMI was  $28.3 \pm 5.9$  kg m<sup>-2</sup> and 67% of the patient population was classified as being overweight or obese (BMI > 25 kgm<sup>-2</sup>). No significant differences in BMI were found between hospitalised and non-hospitalised patients. The majority of the patients had experienced weight loss when comparing current weight with regular weight; 26% had lost 5-10 kg and 12% had lost more than 10 kg. More than one-third of the patients had experienced weight (re-)gain in the month before the first consultation with the primary care dietitian. However, 24% of hospitalised patients and 12% of non-hospitalised patients had experienced weight loss of 5%-10% in the month before the first consultation. Data on body composition are not shown as a result of numerous missing data.

In Table 2, the risk of sarcopaenia assessed by the SARC-F questionnaire at the first dietetic consultation is shown: 44% of the patients were at high risk of sarcopaenia. Hospitalised patients were more frequently at high risk of sarcopaenia compared to nonhospitalised patients (55% vs. 34%). Patients with a high risk of sarcopaenia were significantly older (60  $\pm$  15 years) than patients with no risk of sarcopaenia (52  $\pm$  14 years).

### Nutrition-related complaints

Only a minority of patients (17%) did not report any nutrition-related complaint at the first dietetic

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	Total group ( <i>n</i> = 246)	Hospitalised $(n = 100)^{a}$	Non-hospitalise $(n = 133)^{a}$
Gender, <i>n</i> (%)			
Men Women	97 (39) 149 (61)	58 (58) 42 (42)	32 (24) 101 (76)
Age (mean ± SD)	$n = 244^{a}$ 57.2 ± 15.9	$n = 99^{a}$ 64.3 ± 12.8	$n = 132^{a}$ 52.3 ± 15.7
BMI (mean ± SD)	$n = 235^{a}$	$n = 98^{\mathrm{a}}$	$n = 126^{a}$
	$28.3 \pm 5.9$	$28.3 \pm 5.2$	$28.2\pm6.4$
< 18.5 kg m <sup>-2</sup> 18.5-25 kg m <sup>-2</sup> 25-30 kg m <sup>-2</sup> 30-40 kg m <sup>-2</sup> > 40 kg m <sup>-2</sup>	4 (2) 74 (31) 72 (31) 79 (33) 6 (3)	1 (1) 27 (28) 37 (38) 31 (31) 2 (2)	3 (2) 45 (36) 31 (25) 44 (35) 3 (2)
Weight change over the month before first consultation with primary care dietitian, $n$ (%)	<sup>a</sup> <i>n</i> = 176	<sup>a</sup> n = 75	<sup>a</sup> n = 94
Weight gain more than +5 kg Weight gain +1 to +5 kg Stable weight: -1 to +1 kg -1 to -5 kg -5 to -10 kg More than -10 kg	14 (8) 48 (27) 45 (26) 36 (20) 21 (12) 12 (7)	7 (9) 25 (33) 8 (11) 15 (20) 12 (16) 8 (11)	6 (6) 21 (22) 35 (37) 21 (22) 8 (9) 3 (3)
Weight loss over the month before first consultation with primary care dietitian, $n$ (%)	$n = 176^{a}$	$n = 75^{\mathrm{a}}$	$n = 94^{\mathrm{a}}$
< 5% 5%-10% > 10%	140 (80) 30 (17) 6 (3)	53 (71) 18 (24) 4 (5)	82 (87) 11 (12) 1 (1)
Weight change compared to regular weight, $n$ (%)	$n = 209^{a}$	$n = 88^{\mathrm{a}}$	$n = 118^{a}$
Weight gain more than 5 kg Weight gain 1–5 kg Stable weight: -1 to +1 kg -1 to -5 kg -5 to -10 kg More than -10 kg	19 (9) 13 (6) 41 (20) 57 (27) 54 (26) 25 (12)	4 (5) 6 (7) 9 (10) 24 (27) 28 (32) 17 (19)	14 (12) 7 (6) 32 (27) 32 (27) 26 (22) 7 (6)
Weight loss compared to regular weight, <i>n</i> (%) < 5% 5%–10% > 10%	n = 209 <sup>a</sup> 1'28 (61) 59 (28) 22 (11)	n = 88 <sup>a</sup> 41 (47) 30 (24) 17 (19)	n = 118 <sup>a</sup> 84 (71) 29 (25) 5 (4)

<sup>a</sup>Data were not fully available for all patients: the n within the table depicts the number of patients with available data.

Abbreviation: BMI, body mass index.

consultation. Fifty-nine per cent of patients reported more than one nutrition-related complaints. Figure 1 shows the nutrition-related complaints reported at the first consultation. The five most frequently reported complaints for both hospitalised and non-hospitalised patients were: a decreased appetite (58%), shortness of breath (56%), changed taste (53%), loss of taste (51%) and feeling of being full (45%). Almost one in three patients experienced nausea and non-hospitalised patients experienced nausea more often than hospitalised patients (25% vs. 18%).

Of the four additionally nutrition-related complaints, fatigue was most common; 84 out of 85 patients (99%) reported fatigue at the first consultation. Muscle weakness was reported by 56 out of 64 patients (88%). Seventeen out of 54 patients (31%) reported a loss of smell and 13 out of 48 patients (27%) reported a changed smell. The nutrition-related complaints reported at

**TABLE 1** General characteristics andnutritional status of patients withCOVID-19 at first dietetic consultation by aprimary care dietitian

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Question

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Total

group

(n = 88)

Non-

hospitalised

(n = 44)

Hospitalised

(n = 44)

<b>TABLE 2</b> SARC-F in patients with
COVID-19 at first dietetic consultation by
primary care dietitian

а

Strength: How much difficulty	do	yo
have in lifting and carrying	10	1b/

have in	lifting and	carrying	1(
$5ka^2 n$	(%)		

 $\geq$  4 points, *n* (%)

IHND

5 Kg., <i>n</i> (70)			
None Some A lot or unable	25 (28) 43 (49) 20 (23)	8 (18) 24 (55) 12 (27)	17 (39) 19 (43) 8 (18)
Assistance in walking: How much difficulty do you have walking across a room?, <i>n</i> (%)			
None Some A lot, use of aids or unable	46 (52) 36 (41) 6 (7)	20 (46) 19 (43) 5 (11)	26 (59) 17 (39) 1 (2)
Rise from a chair: How much difficulty do you have transferring from a chair or bed?, $n$ (%)			
None Some A lot or unable without help	45 (51) 38 (43) 6 (6)	16 (36) 26 (59) 2 (5)	29 (66) 12 (27) 3 (7)
Climb stairs: How much difficulty do you have climbing a flight of 10 stairs?, $n$ (%)			
None Some A lot or unable	14 (16) 50 (57) 24 (27)	4 (9) 25 (57) 15 (34)	10 (23) 25 (57) 9 (20)
Falls: How many times have you fallen in the past year?, <i>n</i> (%)			
None 1–3 falls ≥ 4 falls	77 (88) 11 (12) 0	35 (80) 9 (20) 0	42 (96) 2 (5) 0
Total score (mean $\pm$ SD)	$3.3 \pm 2.4$	$3.9 \pm 2.3$	$2.7 \pm 2.3$



39 (44)

24 (55)

15 (34)

### FIGURE 1 Nutrition-related complaints of patients with COVID-19 at the first dietetic consultation by a primary care dietitian

different points in time (i.e., at first consultation, after 1 month, as well as 2, 3, 4–6 months) are shown in the Supporting information (Table 2).

After 1 month, 18% of hospitalised patients and 45% of non-hospitalised patients did not report any nutritionrelated complaints; this increased to 42% and 46% for hospitalised and non-hospitalised patients, respectively, at 4-6 months of follow-up (Figure 2). Nevertheless, after 4-6 months 37% of hospitalised patients and 36% of non-hospitalised patients still reported more than one

FIGURE 2 The number of nutritionrelated complaints reported by patients with COVID-19 at different points in time





**FIGURE 3** Nutrition-related complaints of patients with COVID-19 at different points in time

nutrition-related complaint. The development of the five most common nutrition-related complaints in time is shown in Figure 3. Not all participants were measured on each time point, which hindered performing longitudinal analyses. The number of patients reporting nutritionrelated complaints decreased after the first consultation, but nutrition-related complaints remained present. In the months after the first consultation, many patients still reported nutrition-related complaints. For example, shortness of breath was experienced by 38% of the patients after 1 month, by 33% after 3 months and by 30% after 4-6 months. After 4-6 months, the most frequently reported nutrition-related complaints were changed taste (32%), loss of taste (30%) and shortness of breath (30%). The mean visual analogue score for appetite was and remained low (< 70%), especially at

the first dietetic consultation by a primary care dietitian. Data on stool frequency and consistency were not shown as a result of numerous missing data.

### **Dietetic consultation**

Data on the dietetic consultations are shown in Table 3. Most patients (61%) were referred by the general practitioner. The median number of dietetic consultations was 5.0 (IQR = 3.0-7.0) and the median number of hours submitted to the health insurance company for reimbursement was 3.3 (IQR = 2.5-4.0); no differences were observed between hospitalised and non-hospitalised patients. More than one-third of the patients received six to eight consultations by a primary care dietitian in the first

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	Total group ( <i>n</i> = 246)	Hospitalised ( <i>n</i> = 100)	Non- hospitalised $(n = 133)$
Referring physician, <i>n</i> (%) Hospital dietitian General practitioner Physiotherapist Direct access Transfer from hospital without transfer dietitian Transfer from a dietitian from a nursing home or rehabilitation ward	$n = 241^{a}$ 41 (17) 146 (61) 40 (17) 11 (5) 8 (3) 4 (2)	$n = 98^{a}39 (40)$ 44 (45) 7 (7) 3 (3) 5 (5) 4 (4)	<sup>a</sup> = 131 2 (2) 96 (73) 30 (23) 7 (5) 2 (2) 0
Number of consultations (median, IQR)	$a_n = 166$ 5.0 (3.0–7.0)	$a_n = 62$ 5.0 (4.0–7.3)	$a_n = 98$ 5.0 (3.0–7.0)
$ \begin{array}{c} 1 \\ 2-3 \\ 4-5 \\ 6-8 \\ \geq 9 \end{array} $	10 (6) 34 (20) 51 (31) 58 (35) 13 (8)	3 (5) 8 (13) 21 (34) 23 (37) 7 (11)	7 (7) 25 (25) 28 (28) 33 (34) 5 (5)
Number of hours submitted to the health insurance company (median, IQR)	$n = 161^{a}3.3$ (2.5-4.0)	$n = 67^{a}3.3$ (2.5-4.0)	$n = 88^{a}3.0$ (2.5-4.0)
$\leq$ 3 h 3-7 h $\geq$ 7 h	78 (48) 78 (48) 5 (4)	32 (48) 32 (48) 3 (4)	46 (52) 40 (46) 2 (2)
Method of performing the dietetic consultation, <i>n</i> (%) Completely remote Completely face-to-face Blended care	<sup>a</sup> n = 159 42 (26) 79 (50) 38 (24)	<sup>a</sup> n = 65 27 (42) 23 (35) 15 (23)	<sup>a</sup> n = 93 15 (16) 56 (60) 22 (24)
Reason for closing dietetic treatment, $n$ (%) Treatment goals were achieved Treatment is closed at request of the patient The patient died The patient was discharged from the care of the institution	$n = 155^{a}116 (75)$ 35 (22) 3 (2) 1 (1)	n = 61 <sup>a</sup> 44 (72) 17 (28) 0 0	$n = 89^{a}67 (76)$ 18 (20) 3 (3) 1 (1)

TABLE 3 Dietetic consultation by primary care dietitians

<sup>a</sup>Data were not fully available for all patients: the n within the table depicts the number of patients with

Abbreviation: IQR, interquartile range.

available data.

4-6 months. Fifty percent of the patients were treated completely face-to-face, both at the practice site or via a home visit; non-hospitalised patients were treated completely face-to-face more frequently than hospitalised patients (60% vs. 35%, respectively). Hospitalised patients were treated completely remote more often (42% vs. 16%). In 80% of the patients, a physiotherapist was involved during treatment by a primary care dietitian. In 13% of the patients, the consistency of the meals needed to be adjusted. Oral nutritional supplements were prescribed in 49% of the patients at any time during the dietetic treatment, and tube feeding was not prescribed at all. The treatment goals were achieved in 75% of the patients at the end of the dietetic treatment.

### DISCUSSION

The present study demonstrates that patients with COVID-19 receiving dietetic treatment in primary care experience a large number of nutrition-related complaints until several months after infection. Nutrition-related complaints improved over time, but remained highly prevalent, both in hospitalised and non-hospitalised patients. At first consultation with the primary care dietitian, the majority of the patients had experienced weight loss, although some had started re-gaining weight. Still, the majority of the patient population (67%) was classified as being overweight or obese and 44% of the patients were at high risk of sarcopaenia.

Two out of three patients were older than 50 years of age and hospitalised patients were significantly older compared to non-hospitalised patients. These findings are in line with previous studies that found that older adults are more susceptible to severe COVID-19 and more likely to be hospitalised. This can be explained by the fact that older adults more frequently present multiple comorbidities and have a weaker immune function.<sup>28–30</sup> The present study also found that hospitalised patients were more frequently overweight or obese. This finding is in line with previous studies that found that a higher BMI may lead to more severe disease symptoms which may require hospital admission more often.<sup>12,17,30,31</sup>

The majority of the patients had experienced weight loss when comparing current weight with regular weight. However, more than a one-third of the patients had experienced weight (re-)gain in the month before the first consultation. It is likely that patients had lost weight during acute infection and (re-)gained weight again in the recovery phase. The prospective part of COVOED study, which monitored patients during hospitalisation and after discharge, also showed (re-)gain of weight after discharge.<sup>11</sup>

Previous studies have shown a high risk of malnutrition in patients with COVID-19, especially in hospitalised patients.<sup>16–18</sup> Based on the data collected in the present study we were unable to determine how many patients were malnourished because the required data to assess malnutrition according to the GLIM criteria<sup>32</sup> were not systematically recorded. However, weight loss and risk of sarcopaenia (two phenotypic criteria) were frequently observed, as well as nutrition-impacting symptoms (e.g., loss of taste or smell and poor appetite; two aetiologic criteria). Thus, we assume that a fair amount of patients may have met the malnutrition criteria, even in this group of patients that was mostly obese and not hospitalised.

Previous studies have shown that COVID-19 is associated with a high risk of sarcopaenia as a result of skeletal muscle-related symptoms, such as loss of muscle mass and strength.<sup>11,14,19–21</sup> The present study found that 55% of the hospitalised patients were at high risk of sarcopaenia at first consultation. Patients who were never hospitalised were less likely to have a high risk of sarcopaenia, but still more than one-third were at high risk. The results of the prospective COVOED study showed that, among hospitalised patients only, 73% of the patients had a high risk of sarcopaenia during hospital admission and 56% of the patients still had a high risk of sarcopaenia in the first dietetic consultation after discharge.<sup>11</sup> Based on the results of this study and previous studies, treatment by a physiotherapist and dietitian should be considered, especially in patients with a high risk of sarcopaenia.<sup>33,34</sup> Additional measurements of strength and body composition are necessary to establish the diagnosis of sarcopaenia.<sup>34</sup>

The results of the present study showed that patients with COVID-19 receiving dietetic treatment in primary care experience a wide range of nutrition-related complaints during recovery, both in patients admitted to the hospital and in patients never admitted to the hospital. The number of patients reporting one or more nutrition-related complaints decreased more rapidly in non-hospitalised patients compared to hospitalised patients. However, after 4–6 months of follow-up, this number was almost the same with 58% of hospitalised and 54% of non-hospitalised patients still reporting nutrition-related complaints. It should be noted that this may be because patients with multiple complaints were still receiving dietetic treatment after months and were therefore included in the follow-up analyses.

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Even after several months many patients still reported nutrition-related complaints such as a changed taste, loss of taste, shortness of breath and decreased appetite. This supports data from other studies showing that many complaints remain for long periods after infection with COVID-19. A study by Blomberg et al.<sup>8</sup> conducted in 247 home-isolated and 65 hospitalised patients, showed that 61% of all patients had persistent symptoms at 6 months of follow-up. Most reported persistent symptoms were fatigue and disturbed smell and/or taste. All nutrition-related complaints presented in the present study are likely to influence the nutritional intake of patients. In general, disease can result in multiple nutrition-related complaints such as loss of appetite which may lead to reduced food intake and/or decreased nutrient absorption.<sup>12</sup>

The findings of the present study should be interpreted in light of the limits of the study design. First, a retrospective study design was used, resulting in missing data. Second, it was not possible to collect the same data at the same time points for each patient. Therefore, data were accumulated per time point to make it possible to show follow-up data on the nutrition-related complaints. It should be noted that each time point involved different patients, which hindered performing longitudinal analysis. Unfortunately, we were not able to accumulate follow-up data on risk of sarcopaenia because of numerous missing data. Additionally, we had to rely on the SARC-F screening tool to obtain an indication of sarcopaenia risk. Future projects need to determine the amount and loss of muscle mass and strength in patients with COVID-19. Another consideration is that we had difficulties interpreting weight changes over time, as referral diagnosis ("patient wants to gain weight" vs. "patient wants to lose weight") was not recorded. Patient characteristics of included patients are comparable to COVID-19 populations described by others for age, gender and BMI,<sup>12,17,22</sup> and therefore we assume that the study is representative for the patient population in 2020, which was most likely to have had the Wuhan-variant of the Coronavirus SARS-CoV-2. Different variants may cause different symptoms.

An important strength of the present study is that the data provides insight into the nutritional status, risk of sarcopaenia and nutrition-related complaints of patients

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NUTRITIONAL PROBLEMS OF PATIENTS WITH COVID-19

with COVID-19 visiting a primary care dietitian. We included both patients admitted to the hospital and patients never admitted to the hospital. To date, most nutrition studies have focused on hospitalised patients with severe COVID-19 and only a small number of studies was performed in non-hospitalised patients. When comparing the results of the present study with the results of the prospective COVOED study,<sup>11</sup> performed in hospitalised patients only, the most striking revelation is that nutrition-related complaints over time are independent of hospitalisation and continue to last over many months after infection. The present study supports results from previous studies and also contains new COVID-19-related information important for dietetic care. Because COVID-19 is a relatively new disease and the long-term consequences are still unclear, many more studies are needed. International dietary management guidelines were established soon after the COVID-19 outbreak, but most of these were written before the true severity and duration of nutrition-related complaints were known. The results of the present study contribute to further improvements of the care offered by primary care dietitians.

### CONCLUSIONS

In conclusion, the majority of patients with COVID-19 had experienced unintentional weight loss due to COVID-19, yet more than one third had experienced weight (re-)gain in the month before the first consultation with a primary care dietitian. Additionally, 29% of hospitalised patients and 13% of non-hospitalised patients had experienced more than 5% weight loss in the month before the first consultation. More than one-half of hospitalised and more than one-third of nonhospitalised patients had a high risk of sarcopaenia. Nutrition-related complaints were highly prevalent in patients with COVID-19 visiting a primary care dietitian, both in patients admitted to the hospital and in patients never admitted to the hospital. Of these complaints, decreased appetite, shortness of breath, changed or loss of taste and feeling of being full were most reported. Nutrition-related symptoms improved over time, but remained highly prevalent until several months after infection.

The risk of a poor nutritional status and high risk of sarcopaenia should be considered, especially in combination with persistent nutrition-related complaints as a result of COVID-19. Measurement of strength and body composition is therefore an essential part of the diagnosis and evaluation by a primary care dietitian.

### AUTHOR CONTRIBUTIONS

Hinke M. Kruizenga, Nicolette J. Wierdsma and Peter J. M. Weijs designed the research. Anne I. Slotegraaf, Hinke M. Kruizenga and Nicolette J. Wierdsma conducted the research. Anne I. Slotegraaf analysed data. Hinke M. Kruizenga and Marian A. E. de van der Schueren contributed to the analyses and interpretation of the data. All authors critically reviewed the manuscript 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.

### ETHICAL STATEMENT

The study protocol was reviewed by the medical ethics review board of VU University Medical Center (IRB00002991), who decided that the Medical Research Involving Human Subjects Act (WMO) did not apply for this study. A general informed consent was provided by the patients to use medical data for research purposes.

### TRANSPARENCY STATEMENT

The authors affirm that this manuscript is at 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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### 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. How to cite this article: Slotegraaf AI, de van der Schueren MAE, Wierdsma NJ, Weijs PJM, Kruizenga HM. Nutritional problems of patients with COVID-19 receiving dietetic treatment in primary care. J Hum Nutr Diet. 2023;36:20–30. https://doi.org/10.1111/jhn.13053 DOI: 10.1111/ihn.13043

### PRINCIPLES OF NUTRITION AND DIETETICS

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 Abstract

 Background: Communities of practice have been proposed as a workforce development strategy for developing dietitians, yet little is known about how

A realist evaluation of a community of practice for dietitians

and nutritionists working in Aboriginal and Torres

development strategy for developing dietitians, yet little is known about how they work and for whom, as well as under what circumstances. We aimed to understand the mechanisms by which dietitians working in Aboriginal and Torres Strait Islander health benefit from communities of practice.

**Methods:** A realist evaluation of 29 interviews with non-Indigenous dietitians and nutritionists was employed, which was conducted over the course of two communities of practice (2013 and 2014) and follow-up interviews in 2019. Programme theory was developed from analysis of initial interviews and used to recode all interviews and test theory. The identification of patterns refined the programme theory.

**Results:** Six refined theories were identified: (1) a community of practice fosters the relationships that support navigation of the many tasks required to become more responsive health professionals; (2) committed and open participants feel supported and guided to be reflexive; (3) sharing, reflexivity, feedback and support shift awareness to one's own practice to be able to manoeuvre in intercultural spaces; (4) through sharing, feedback, support and collaboration, participants feel assured and affirmed; (5) connection through feelings of understanding and being understood contributes to commitment to remain working in the area; and (6) through sharing, feedback, support and collaboration, participants with varied experience and roles see the value of and gain confidence in new perspectives, skills and practices.

**Conclusions:** Further research is required to test this model on a much larger scale, with communities of practice inclusive of Aboriginal and non-Aboriginal health professionals together, and across a diverse group of dietitians.

### **KEYWORDS**

cultural competence, group learning, Indigenous, professional development, workforce development

Annabelle Wilson and Marian Cornett contributed equally to this work.

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### Key points

- We conducted a realist evaluation of 29 interviews with non-Indigenous dietitians and nutritionists engaged in communities of practice to understand how communities of practice work and for whom, as well as under what circumstances.
- Using a series of interviews over a period of 6 years, the evaluation found that a range of outcomes (responsive health professionals, ability to manoeuvre in intercultural spaces, retention in this area of practice, increased confidence) were possible in contexts where participants were committed, open and willing to share and were activated by being supported and guided through reflexive practice, peer feedback and being understood.
- Engaging in reflexive practice and peer feedback with people who understand your work experiences (empathy) where new perspectives and practices are valued, were critical for supporting achievement of outcomes.

### INTRODUCTION

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All health professions are recognised for their important role in providing culturally responsive and effective health care for Aboriginal and Torres Strait Islander peoples.<sup>1</sup> Simultaneously, health professions are criticised for perpetuating healthcare provision that reinforces racist stereotypes and dismissing the complex interplay between social, political and historical determinants affecting Aboriginal peoples' experiences of health care.<sup>2–4</sup> Having a suitably qualified and culturally capable health workforce is a priority for governments and health agencies internationally. The capacity of the existing workforces together with strategies to support the education of workforces in training are essential for ensuring local and global health needs are met and that the perpetuation of biased and exclusionary health provision is minimised.<sup>5</sup>

The nutrition workforce is an important part of the prevention and management of many of the health issues that disproportionally impact Aboriginal and Torres Strait Islander peoples in Australia.<sup>6–9</sup> Although health priorities vary across countries, Aboriginal and Torres Strait Islander health, and indeed nutrition, is a recognised priority for all Australian governments.<sup>10</sup> The experiences of Aboriginal and Torres Strait Islander peoples in Australia can provide learnings for other First Nations' communities internationally, with similar health and social outcomes seen in First Nations' communities globally<sup>11</sup> and the need for culturally safe and responsive care to be provided regardless of location.<sup>12</sup> Dietitians are a key part of the nutrition workforce. Dietitians are health professionals who apply the science of food and nutrition to promote health, and prevent and treat disease to optimise the health of individuals, families, communities and populations.<sup>13</sup> They play an important role in working with Aboriginal and Torres Strait Islander communities, yet there evidence to suggest that dietitians need to be more equipped to be culturally safe and responsive.<sup>14</sup> The overwhelming majority of dietitians in Australia

are non-Aboriginal people, with only a total of 32 individual dietitians who self-identified as Aboriginal and/or Torres Strait Islander in 2020.<sup>15</sup> There is also lack of evidence of effective workforce development strategies for dietitians working in Aboriginal and Torres Strait Islander health.

Dietitians are trained within an evidence-based paradigm that prioritises Western knowledge systems<sup>16</sup> and positivist biomedical sciences<sup>17</sup> with variable approaches to teaching Aboriginal and Torres Strait Islander health that differ between universities.<sup>18,19</sup> This does not adequately prepare dietitians to work within Aboriginal and Torres Strait Islander communities, nor across worldviews and knowledge systems that differ from how they were taught to approach their practice. Studies report perceptions of such cross cultural work as being 'too hard' and dietitians being 'too scared' to try.<sup>20,21</sup> The implication of this is that, for Aboriginal peoples seeking the services of dietitians, their healthcare will be a cross-cultural experience with non-Aboriginal dietitians by necessity and not by choice, which in turn results in racism and culturally unsafe practice that may have an impact on their nutrition and health outcomes.<sup>22,23</sup>

Non-Aboriginal dietitians and other health professionals working in Aboriginal health settings have identified that awareness of the ongoing impacts of colonisation, personal ideologies, collegial relationships with Aboriginal health professionals, opportunities for self-reflection and supportive workplaces are important factors for facilitating effective workers.<sup>20</sup> Additionally, non-Aboriginal dietitians and health professionals report that professional isolation, risk of burn out, lack of confidence, feelings of discomfort and fear are individual factors which are barriers for dietitians continuing to work in Aboriginal health settings.<sup>20,24</sup> Therefore, methods to support and sustain established dietitians in Aboriginal health settings are an important contribution to the broader Aboriginal health equity agenda, as well as for First Nations communities globally.

Effective workforce development for health professions, often termed continuing professional development, includes a range of strategies for developing personal and professional attributes of the professional and health teams to deliver safe and effective health systems and services.<sup>25</sup> Of the evidence that exists for professional development in Aboriginal and Torres Strait Islander health, professional networks or group mentoring have been shown to contribute to dietitians' decisions to begin and continue working in rural and remote locations<sup>26</sup> and in Aboriginal and Torres Strait Islander health.<sup>27</sup> Formalised professional networks, with regular, facilitated, guided and structured reflective practice, peer mentoring groups or communities of practice, have been shown to be an effective workforce capacity-building intervention for dietitians,<sup>28,29</sup> public health nutritionists working with Aboriginal and Torres Strait Islander stores,<sup>30</sup> and dietitians/nutritionists working in Aboriginal and Torres Strait Islander health.<sup>31–33</sup> According to communities of practice theory, learning is a social process. Through participation in a community with shared experience of practice learning takes place. <sup>34–36</sup> The ways in which communities of practice support dietitians' work with Aboriginal and Torres Strait Islander health, and also First Nations health globally, and why they work and under what circumstances, are yet to be described.

In the present study, we take a realist approach to evaluating a community of practice for dietitians and nutritionists working in Aboriginal and Torres Strait Islander Health. Realist approaches in nutrition and dietetics have been proposed as an effective approach at dealing with the complexity of nutrition interventions.<sup>37</sup> The present study aimed to identify the outcomes achieved by the community of practice and to elicit for whom and under what circumstances they are achieved. Although conducted in the specific context of Aboriginal and Torres Strait Islander health in Australia, the outcomes identified are of relevance to, and will provide learnings for, dietitians working with First Nations communities globally.

### METHODS

### Study design

A realist evaluation of existing longitudinal interview data was conducted because previous evaluations of the community of practice had been unable to determine the conditions in which outcomes were achieved and what underlying factors triggered the outcomes. This realist evaluation focussed on an existing community of practice implemented and evaluated to strengthen the capacity of dietitians with a specific role in working to improve the nutrition and health of Aboriginal and Torres Strait Islander communities. The design of the community of practice was based on similar initiatives<sup>28,29</sup> and implemented and facilitated by some of



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the investigators (AW, RD and CP). This community of practice was developed based on Wenger's community of practice theory whereby a group of people, with a common interest, come together to share resources and create new knowledge to advance a topic of professional practice.<sup>38</sup>

Realist approaches to evaluation aim to unpack and understand why complex programmes or interventions do or do not work.<sup>39</sup> Realist approaches are theory-driven, where initial theory development (programme theory) guides the process from the outset and subsequent data extraction and synthesis informs theory refinement. The refined theory aims to explain why complex programmes or interventions do, or do not, work and in which particular contexts or settings.<sup>39</sup> The present study was guided by the standards for reporting realist evaluations.<sup>40</sup>

In realist evaluation, interventions or programmes are proposed to lead to outcomes through the action of mechanisms that are causal within certain contexts. Realist evaluation aims to identify and explain underlying mechanisms and the contexts in which they produce certain outcomes.<sup>39</sup> Realist evaluation posit that it is not the intervention itself that creates the change but rather it is people in response to that intervention who create the change. Therefore, mechanisms usually involve reasoning, choices, norms or collective beliefs. Mechanisms are typically hidden, contextually influenced and produce certain outcomes.<sup>41</sup> In their relationship with outcomes, mechanisms can either cause, or not, the outcome.<sup>42</sup> Realist evaluation also suggest that the relationship between an intervention or programme, the underlying mechanisms and the outcomes of a programme or intervention are complex, nuanced and sensitive to contextual variations.<sup>39</sup> Context may be material resources and social structures or the elements within a particular setting.<sup>41</sup> Context may also relate to the individuals participating in programmes, to stakeholder inter-relationships, to institutional arrangements in which programmes sit and/or wider cultural, economic and/or societal settings for programmes.<sup>43</sup>

In realist evaluation, it is the relationships between interventions, context, mechanism and outcomes, otherwise known as Context (C), Mechanism (M), Outcome (O) configurations, that are of primary interest.<sup>39</sup> Realist evaluations aim to identify patterns, termed demiregularities, across CMO configurations, which are used to confirm and/or refine the programme theory.<sup>10,44</sup> As such, our evaluation sought to understand what was it about this intervention (the community of practice) that worked (or did not) (outcomes) and under what circumstances (contexts) and how and why (mechanisms).

### Data collection

In the initial intervention, two groups of dietitians were involved in a community of practice over the period of 2013 and 2014. Each community of practice lasted approximately 12 months and commenced with a face-to HND

face-workshop to facilitate relationship building among participants to support the establishment of trust, known to be important for group performance.<sup>28,29</sup> All participants identified as non-Aboriginal people, were working in dietetic roles in Aboriginal health settings and self-nominated to participate in the community of practice. Details of the programmes and their evaluation are provided elsewhere.<sup>31,32</sup> Multiple methods for evaluations were undertaken. Initially, interviews aimed to evaluate participants' experiences of the intervention, its quality and functionality, and support of practice, practice change and workforce retention (qualitative interviews).<sup>33</sup> In addition, in 2019, 5 years after the initial intervention, a follow-up interview study was conducted that aimed to evaluate sustained impact on practice and retention in the field, the reasons underpinning this sustained impact and the contexts in which it was present.<sup>45</sup> Quantitative data collected as part of the initial evaluation were not included as a result of advancements in methods used to assess cultural competency<sup>46</sup> and therefore the inadequacy of the cultural competency assessment originally used. All qualitative interview data was pooled to inform this realist analysis.

Participants of the community of practice involved in previous evaluation studies were contacted by the investigators and consent sought to use previous interview data. Of the 17 individuals who participated across the two community of practice, 16 consented to include their data, resulting in 29 interviews being included in the realist synthesis (Tables 1 and 2).

### Data analysis

A realist analysis of 29 qualitative interviews was conducted to examine the outcomes (short-term/long-term) and for whom or in what contexts these outcomes occurred, as well as under what circumstances, and how and why (mechanisms). The interviews from the two community of practices previously analysed <sup>33</sup> together with the mid-range theory of communities of practice as conceived and developed by Lave and Wenger,<sup>34</sup> Wenger<sup>35,38</sup> and others,<sup>36</sup> informed the development of the initial of programme theory for the realist evaluation. One investigator (MC) independent of the initial research drafted the initial programme theory and presented it to the other investigators for consideration, given their intricate understanding of the intervention, and revised after feedback.

The following propositions were developed as the programme theory:

• Where participants have shared experience and shared experience of 'not knowing' and conflictedness/incongruence/dissonance/discomfort (C), the community of practice (I) provides a safe place that, through trust, supports vulnerability and sharing of

 TABLE 1
 Details of interviews conducted over the three time periods

	Interview Year		
Participant number	2013	2014	2019
1	Х		
2	х		
3	х	х	х
4	х	х	х
5	х		
6	х	х	х
7		х	x
8		х	х
9		х	x
10		х	
11		х	x
12		х	х
13		х	
14		х	х
15		х	х
16			x
Total	6	12	11

aspects of practice openly and without judgement (M) that fosters personal and professional reflection and growth (O).

- Where participants share experiences (C), the community of practice (I) provides a forum for understanding, valuing, validating and accepting (M) that supports more effective interaction between professionals through understanding and better communication and relationship building (O).
- Where participants lack confidence (C), the community of practice (I) promotes validation and empowerment/ confidence to adopt new approaches and implement new practice and strategies (M) to improve practice (O).
- Where participants experience isolation in practice (C), the community of practice (I) creates/facilitates/encourages feelings of connectedness and provides social support networks that facilitate sharing and collaboration (O) to support learning (tacit, implicit and self-knowledge) and an increase of knowledge and skills (O) and that also reduce burden/workload and feelings of isolation (O), which in turn can improve career satisfaction and job retention (O).

The programme theory was then used to guide data extraction and synthesis, which in turn were used to further refine the theory. This process involved re-coding data from all 29 interviews with the assistance of Nvivo,

### TABLE 2 Initial programme theory and revised programme theory

Initial programme theory	Modified programme theory	Key changes
Where participants have shared experience and shared experience of 'not knowing' and conflictedness/incongruence/dissonance/ discomfort (C), the community of practice (I) provides a safe place that, through trust, supports vulnerability and sharing of aspects of practice openly and without judgement (M) which fosters personal and professional reflection and growth (O)	When participants recognise that working in Aboriginal and Torres Strait Islander health requires multiple ways of being and working (C) the community of practice (I) fosters relationships that form the foundation of an empathetic environment (M) to navigate the various tasks of becoming a more responsive health professional working in Aboriginal and Torres Strait Islander Health (O)	The original context of 'not knowing' was distilled and refocused to recognise the importance of participants' <i>acknowledgement of the validity</i> of different knowledge systems and different ways of working. The original mechanism was refined to more succinctly describe the resource and reasoning contributing to the outcome. The original outcome was refined to more accurately describe the outcome to be more than just personal and professional reflection and growth but actually a more responsive professional
Where participants share experiences (C) the community of practice (I) provides a forum for understanding, valuing, validating and accepting (M) which supports more effective interaction between professionals through understanding and better communication and relationship building (O)	When participants who are committed and open to improving their practice in Aboriginal and Torres Strait Islander health (C) and take part in the community of practice (I), they feel supported and guided to be reflexive by facilitators (M) becoming self-aware, insightful, and more confident in themselves (O)	Refocus of this context to include the importance of committed <i>and open</i> <i>participants</i> .Shift from specific and outward focussed outcomes to general inward-focussed outcome
Where participants lack confidence (C) the community of practice (I) promotes validation and empowerment/confidence to adopt new approaches and implement new practice and strategies (M) to improve practice (O)	When skilled facilitators work with committed participants with varied experience and roles (C) the sharing, reflexivity, feedback and support offered (M) shifts consciousness to their own practice to be able to manoeuvre in intercultural spaces and advocate through speaking 'with and not for' (O)	Change in focus of this outcome from general 'improve practice' to more specifically what this improved practice might look like – a move from being directive to becoming health professionals who respond to and work with Aboriginal and Torres Strait Islander communities a shift from 'for' to 'with'
Where participants experience isolation in practice (C) the community of practice (I) creates/facilitates/encourages feelings of connectedness and provides social support networks that facilitate sharing and collaboration (O) that supports learning (tacit, implicit and self-knowledge) and increase of knowledge and skills (O), and which reduce burden/workload and feelings of isolation (O) which in turn can improve career satisfaction and job retention (O)	Where participants with varied experience and roles share the lived experience of working in Aboriginal and Torres Strait Islander health (C) the community of practice (I) promotes connection through feelings of understanding and being understood through sharing, feedback and support (M) which contributes to their commitment to remain working in Aboriginal and Torres Strait Islander health	Broadening of this context to encompass <i>all</i> workers in Aboriginal and Torres Strait Islander Health and the outcome of commitment to working in and advocating for Aboriginal and Torres Strait Islander health plus more deep description of the outcome over and above retention and satisfaction
	When participants with varied experience and roles (C) share, feedback, support, and collaborate in the community of practice they can see the value of and gain confidence in new perspectives, skills and practices (M) which they take back to their communities, workplaces, colleagues and students, and integrate into their practice (O)	New CMOC

Abbreviations: C, context; I, intervention; M, mechanism; O, outcome.

v12 2018 (QSR International) by one investigator (MC) who was familiar with realist approaches yet independent of the initial research. Initially, a deductive approach to coding was employed where individual contexts (C), mechanisms (M) and outcomes (O) derived from the initial programme theory were identified in the data, a process that also helped familiarise the analyst with the interviews. The code (e.g., particular context) was a label given to a section of text. After the deductive approach

was completed, an inductive approach was employed where contexts, mechanisms and outcomes not identified in the programme theory were also coded by the same investigator and added to the initial coding framework. The codes were then compared with the mid-range theory at this point with differences noted and codes clarified based on this theory.

Data were further consolidated by a process of choosing an outcome of interest and then identifying

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the mechanism/s most often associated with this outcome to form a MO dyad,<sup>47,48</sup> a process repeated until all outcomes were correlated with mechanisms. This formation of dyads was guided by our programme theory (e.g., that through shared repertoire learning occurs) and, again, attention was given to any mechanisms and outcomes not identified in the original theory. In addition, specific contexts associated with specific mechanisms were also identified to form CM dyads (e.g., shared understandings).<sup>47,48</sup> Finally, patterns of specific contexts or outcomes linked to these dyads were identified and compiled into six draft CMO configurations (CMOCs) for further refining.<sup>47,48</sup>

As with other realist research, to assist with the validation of emerging findings,  $^{49-51}$  the six draft configurations were presented to stakeholders, in this case all investigators, including three who were insider researchers. At a series of meetings and through personal reflections and collaboration, these draft CMOCs were compared with the initial programme theory. Relationships with the programme theory were discussed, interpretations shared, differences noted and debated based on realist methods (e.g., empathic environment as a context or mechanism or both), and conceptualisations re-worked and distilled until final CMO configurations were agreed. The members of the research team who were insiders as a result of their participation in earlier community of practices (AW, CP and RD),<sup>52</sup> along with the Aboriginal (Waljen) researcher who brought an outsider perspective as a result of not being involved in earlier community of practices (TM), reflected on their own experiences, worldviews, the data and its interpretation by the independent investigator (MC), and all investigators engaged in reflexive discussions to finalise the theories by consensus.

### RESULTS

The 16 participants included dietitians with between 1 and 20 years of work practice (not necessarily in the Aboriginal and Torres Strait Islander context) who worked across a range of different Aboriginal and Torres Strait Islander health settings (including direct patient care (n=11), population health/policy (n=1) and academia (n=4).

The four initial programme theories were refined, expanded and revised into six revised CMOCs. None of the initial theories were refuted in the data.

### 'Becoming' responsive health professionals

When participants recognise that working in Aboriginal and Torres Strait Islander health requires multiple ways of being and working (C), the community of practice fosters relationships that form the foundation of an empathetic environment (M) to navigate the various tasks of becoming a more responsive health professional working in Aboriginal and Torres Strait Islander Health (O).

The common experience of working in Aboriginal and Torres Strait Islander health connected participants in the community of practice and is the foundation of an environment for being understood and understanding. This shared 'knowing' provided a supportive environment that facilitated reflexive practice by encouraging and supporting participants to both articulate their vulnerability and explore new ways of practise which are client and culture-centred.

There was an, very early on, ability for the group to put something – for anybody to say something – that really put, made them quite vulnerable, and that consistently the group was open and holding of that person, and would share how they resonated with those feelings or had had the same experience, ... That person didn't feel like they wanted to describe all of that, and I was as a facilitator actually able to say, 'This is a group that actually completely understands what you're saying ... We actually know what you're saying, you don't have to explain that. You can just keep going with that conversation (Participant #7)

### Supporting and guiding reflexivity

When participants who are committed and open to improving their practice in Aboriginal and Torres Strait Islander health (C) and take part in the community of practice, they feel supported and guided to be reflexive by facilitators (M) becoming self-aware, insightful and more confident in themselves (O).

Facilitators who were experienced both in Aboriginal and Torres Strait Islander health and in facilitation were seen by participants as being instrumental in encouraging an effective level of introspection and reflexivity at the same time as offering support for them to sit with the discomfort of doing so. This developing *self-awareness* and honest self-assessment forms the foundations of maturing emotional intelligence and self-confidence.

> I guess I wanted to start running an exercise programme, and people in the community had requested it, so I guess before I would've just said, 'Yes, let's start an exercise programme. We'll go and do that', but I guess reflective practice has helped me stop and consult some other people, talk to the community, work out what it is they really want, then move on to the next step. Make

sure you've got all those plans in place and all the background stuff done before you jump straight into running it. It's been a whole lot more successful than any other programme I've started (Participant #15)

### Shifting the lens

When skilled facilitators work with committed participants with varied experience and roles (C), the sharing, reflexivity, feedback and support offered (M) shifts consciousness to their own practice to be able to manoeuvre in intercultural spaces and advocate through speaking 'with and not for' (O).

The breadth and depth of experience shared with the community of practice enables participants to see that there are other ways of being and doing and that there are many voices that need to be listened for and listened to. At the same time, the community of practice supports participants in re-shaping their practices in relation to others' voices – being less directive and becoming health professionals who respond to, and work with, Aboriginal and Torres Strait Islander communities.

I think that, had I not thought about the power of the local voice, I probably would've before maybe overridden that and suggested that another education programme isn't the way to go, but now thinking I'm like, 'That comes from my perspective. If the people in the community, and especially the elders, if that's what they want for their women, then I need to support that', rather than putting my own white professional judgement on the situation (Participant #16)

### Fostering commitment to Aboriginal and Torres Strait Islander health

Where participants with varied experience and roles share the lived experience of working in Aboriginal and Torres Strait Islander health (C), the community of practice promotes connection through feelings of understanding and being understood through sharing, feedback and support (M), which contributes to their commitment to remain working in Aboriginal and Torres Strait Islander health (O).

For many participants, the common experiences of working in Aboriginal and Torres Strait Islander health expressed through the community of practice reassured them that their experiences in Aboriginal and Torres Strait Islander Health were shared, valued and valuable. Being validated and feeling connected and supported helps many see their working in and advocacy for Aboriginal and Torres Strait Islander health as being important. I think that community of practice fosters leadership. I think community of practice fosters optimism and also passion and reassurance so people stay in that role (Participant #7)

For many participants, the storytelling and exchanging of experiences of the community of practice helped them realise that they were not alone in their circumstances and that many experience challenges at times. The experience and wisdom proffered in the community of practice along with encouragement and feedback contribute to participants feeling supported and able to remain working in Aboriginal and Torres Strait Islander health.

> ... I just needed someone to say it's okay, because [she] sat down with me and she said 'no, it's all right, what's going on' and it's really hard to explain the situation, whereas she'd heard it happen before. And then I told the group at the next meeting but if it wasn't for being there and hearing what other people are doing and sitting down alone with [her] and then explaining it further probably at the next [inaudible] I definitely wouldn't have stayed here (Participant #4)

# Contributing to skills and practices that can be shared

When participants with varied experience and roles (C) share, feedback, support and collaborate in the community of practice, they can see the value of and gain confidence in new perspectives, skills and practices (M), which they take back to their communities, workplaces, colleagues and students, and integrate into their practice (O).

Not only did the community of practice support individual introspection and reflexivity, but also it involved the learning of new skills and acquiring of new resources and ideas to be shared elsewhere. Furthermore, new relationships, networks and collaborations all contributed to the proliferation of influence of the community of practice.

> That reflection tool was really good. I used that in our clinical supervision back with our dietitians here and we all used it and then came back the following fortnight and we used that tool to let our frustration, like if anyone had any frustrations ... we all worked through the tool for just that situation and worked out the positives and the negatives and how it could be done better

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so, yeah, we all found that tool really, really positive (Participant #1)

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### DISCUSSION

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Using a realist approach, the present study aimed to understand how a community of practice for dietitians working in Aboriginal and Torres Strait Islander health settings achieved its outcomes, as well as under what circumstances. The evaluation found that a range of outcomes (responsive health professionals, ability to manoeuvre in intercultural spaces, retention in this area of practice, increased confidence) were possible in contexts where participants were committed, open and willing to share and were activated by being supported and guided through reflexive practice, peer feedback and being understood. Engaging in reflexive practice and peer feedback with people who understand your work experiences (empathy), where new perspectives and practices are valued, appeared to be critical for supporting achievement of outcomes. These findings provide key insights into the key contextual factors of, commitment to engaging in workforce development initiatives and being willing to share, which will assist in translating this workforce development initiative to other health workforces, and also provide new insights into previous theories on communities of practice.<sup>35</sup>

The profound impact of peer support on health professionals working in Aboriginal and Torres Strait Islander health was clear in different ways in the present study. Initially, it was the common experience of working in Aboriginal and Torres Strait Islander health that united the participants and, subsequently, this shared place of understanding allowed for a connection around deeper issues. This included the acknowledgement that working effectively in Aboriginal and Torres Strait Islander health requires multiple ways of being and working, which supports the existing literature.<sup>33,53,54</sup> The multiple worldviews that health professionals must engage with when working ethically in Aboriginal and Torres Strait Islander health, especially the interface of western and Aboriginal and Torres Strait Islander knowledge systems<sup>55,56</sup> and Aboriginal and Torres Strait Islander understandings of health and wellbeing, has been recognised previously.<sup>57</sup> Our study provides further evidence that dietitians who engage with Aboriginal and Torres Strait Islander standpoints, worldviews and epistemologies, as well as navigate through the tensions of bringing together knowledge systems in their practice, may experience better job satisfaction and have greater impacts.<sup>18,54</sup> This is important given the established burnout risk and high staff turnover recognised with health professionals working in Aboriginal and Torres Strait Islander health, and also in rural and remote health settings.58

The present study also highlights the specific mechanisms of consciously sharing, reflexivity, feedback and peer support assist health professionals change their practice. This study adds to the literature around reflexivity in Aboriginal and Torres Strait Islander health by highlighting that the presence of a skilled facilitator supporting this journey of reflexivity enables participants to move through such discomfort and become more self-aware, insightful and confident; however, it might be challenging to engage because it can be an uncomfortable experience.<sup>59,60</sup> Our findings build on the Wenger community of practice theory<sup>38</sup> highlighting that it is not merely the people coming together, but also their willingness to share resources and experiences when sharing deep cross-cultural experiences, as well as being committed to advancement, that leads to advancement of practice.

A strength of the present study is the use of realist evaluation in the field of nutrition and dietetics, which is lacking in the discipline.<sup>37</sup> Realist evaluation has been used in the evaluation of public health nutrition interventions<sup>37</sup> and other areas of healthcare, including clinical research translation,<sup>61</sup> healthcare supervision training<sup>62</sup> and medical faculty development.<sup>63</sup> Within this landscape, the present study could be used as an example of how realist evaluation has been used in dietetics and adds to understanding of the important role of context in determining outcomes in health professional practice, which is brought to light with a realist analysis. The positionality of the investigators is a strength of the study. Although the investigators are all academics, our positionality includes multiple worldviews that are brought together, including non-Aboriginal and Torres Strait Islander dietitianacademics (AW, MC, RD and CP) and an Associate Professor of Aboriginal health research who is a Waljen (Aboriginal) Public Health Medicine Physician (TM). Additionally, our insider (RD, AW and CP) and outsider (MC and TM) positions to the original community of practice studies enabled robust dialogues through the research processes. Furthermore, a long-term (5 years) follow-up of interview participants suggests that impacts are maintained. The fact that the interviews were not designed based on realist logic may have prevented the breadth of CMOCs being identified. Another limitation of the present study is that the original community of practice did not involve Aboriginal knowledges and voices. Research is currently being undertaken to identify how this could be achieved.

In conclusion, the present study has identified that a community of practice for non-Indigenous dietitians and nutritionists working in Aboriginal and Torres Strait Islander health settings who were committed and open and willing to share, and supported and guided through reflexive practice, peer feedback and being understood develop confidence, are more responsive health professionals, able to manoeuvre in intercultural spaces and are more likely to stay working in this area. Further research is required to test this model on a much larger scale, with communities of practice inclusive of Aboriginal and non-Aboriginal health professionals together, and also across a diverse group of dietitians working in Aboriginal and Torres Strait Islander health.

### AUTHOR CONTRIBUTIONS

Annabelle Wilson, Robyn Delbridge and Claire Palermo designed the study. Annabelle Wilson and Robyn Delbridge facilitated and participated in the community of practice. Claire Palermo conducted interviews. Annabelle Wilson, Robyn Delbridge and Claire Palermo conducted original analyses for two other papers. Marian Cornett conducted secondary coding and complete extraction in line with realist methodology. Claire Palermo and Marian Cornett completed data synthesis which was verified by Annabelle Wilson, Robyn Delbridge and Tamara Mackean. Annabelle Wilson, Marian Cornett, Claire Palermo drafted manuscript with significant input and approval from Robyn Delbridge and Tamara Mackean.

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### **CONFLICT OF INTEREST**

The authors declare that there are 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 **RAMESES II** reporting standards for realist evaluations. 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.

### ETHICAL STATEMENT

Ethics approval was obtained from the Aboriginal Health Research Ethics Committee of South Australia (04-20-867), Flinders University Social and Behavioural Research Ethics Committee (OH-00248) Monash University Human Research Ethics Committee (21089) and Swinburne University of Technology (20202997-4363).

### TRANSPARENT PEER REVIEW

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### PRINCIPLES OF NUTRITION AND DIETETICS

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# Response to a novel, weight self-awareness plan used in a multi-component lifestyle intervention programme to reduce breast cancer risk factors in older women—Secondary analysis from the ActWELL trial

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### Abstract

Background: The ActWELL randomised controlled trial assessed the effectiveness of a weight management programme delivered by volunteer lifestyle coaches (LCs) in women attending breast clinics. The intervention focused on caloric intake and physical activity, utilising behavioural change techniques including a weight awareness plan (WAP). The current work is a secondary analysis of the ActWELL data and aims to examine the response to the weight self-awareness plan (used as part of the intervention programme). Methods: The LCs invited participants (n = 279) to undertake an implementation intention discussion to formulate a self-weighing (SW) plan. Bodyweight scales were offered, and recording books provided. The physical activity component of the intervention focused on a walking plan assessed by accelerometers. The LCs contacted participants by telephone monthly and provided personalised feedback. Mann-Whitney tests and chi-squared analysis were used to examine the effect of SW on weight change. A qualitative evaluation utilising semi-structured interviews was also undertaken.

**Results:** Most participants (96.4%) agreed to set a weekly SW goal and 76 (27%) requested scales. At 12 months, 226 (81%) returned for follow up. The median (interquartile range) weight change for those who self- reported at least one weight (n = 211) was -2.3 kg (-5.0 to 0.0) compared to -1.2 kg (-5.0 to 0.03) in those who did not (n = 14). Participants who reported weights on more than eight occasions (39%) were significantly more likely (p = 0.012) to achieve 5% weight loss compared to those who weighed less often. Low numbers of accelerometers were returned that did not allow for significance testing. Qualitative data (n = 24) indicated that many participants found the WAP helpful and motivating.

**Conclusions:** Greater adherence to the WAP initiated by volunteer coaches is associated with achieving 5% weight loss.

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# KEYWORDS breast-cancer, self-monitoring, weight Key points Volunteer coaches successfully supported women to lose weight in the ActWELL trial. Secondary analysis demonstrated that adherence to a weight awareness programme was associated with achieving 5% weight loss.

### INTRODUCTION

Excess body fat is known to be associated with at least 13 cancer types, many of which are diagnosed in older years,<sup>1</sup> with the greatest burden occurring in women as a result of the association of obesity with post-menopausal breast, endometrial and ovarian neoplasms.<sup>2</sup> However, there is growing evidence to suggest that weight management (avoidance of weight gain, intentional weight loss in individuals with overweight/obesity and maintenance of weight loss) is associated with decreased cancer incidence.<sup>3–5</sup> In Scotland, the breast cancer community is currently exploring opportunities to support weight management programmes for breast cancer risk reduction, utilising a community asset approach working with existing National Health Service (NHS) Breast screening sites.<sup>6,7</sup>

The ActWELL randomised controlled trial (RCT) was designed to assess the effectiveness of a volunteer delivered weight management programme for women with a body mass index (BMI) > 25 kg m<sup>-2</sup> attending four NHS Scotland Breast Screening clinics.<sup>8</sup> Primary outcomes were changes in measured body weight (kg) assessed by research nurses and physical activity (step count) assessed by accelerometers between intervention and comparison groups at 12 months.<sup>8</sup>

The intervention was based on the COM-B model of behaviour change.<sup>9</sup> This approach was used to increase capability for lifestyle change (e.g., via a volunteer coach delivered personalised programme and providing digital skills to those who sought them), greater opportunities for being physically active (via a pedometer-walking programme and local leisure centre use) and improve motivation for weight management (by raising awareness of lifestyle and breast cancer risk reduction within screening, and the use of goal-setting, action and coping plans). The development of the intervention programme was based on a feasibility trial.<sup>7</sup> The combination of approaches used was influenced by participant acceptability data from the feasibility study with notable concerns over programme duration, coach contact time, content and use of behaviour change techniques and communications generally (e.g., science and evidence, non-judgemental approaches and avoiding guilt). In addition, the need for emphasis on support rather than

education became apparent. These findings are detailed elsewhere.<sup>10</sup> The final programme focussed on altering both caloric intake and physical activity, utilising a range of behavioural change techniques.<sup>11</sup> The programme was delivered by trained volunteer lifestyle coaches (LCs) (managed by the charity Breast Cancer Now) via two (one-to-one) face-to-face visits in local leisure centres and up to nine telephone calls over a 12-month period. The use of volunteers for supporting weight management in this context involved considerable emphasis on selfawareness of body weight (self-monitoring, reporting and feedback) through the use of a weight awareness plan (WAP). Reporting of body weight and feedback was the focus of all nine telephone calls. The trial results demonstrated a clinically relevant reduction in body weight in women randomised to the intervention arm who were more than twice as likely to achieve 5% loss in body weight (odds ratio = 2.20; 95% confidence interval = 1.4–3.4, p = 0.0005)<sup>12</sup> than the comparison group. The major focus of the second primary outcome (increase step count) aimed to assess the impact of personalised, pedometer-based walking plans with discussions on progress being discussed at monthly telephone calls. However, participants were not invited to provide specific pedometer reports (to reduce participant and coach burden). No important differences were detected in step counts between the groups at 12 months follow up.<sup>12</sup>

The importance of self-monitoring in behaviour change programmes has been widely described, <sup>13,14</sup> and has been demonstrated to be linked with greater success in diet and physical activity interventions, in line with the principles of control theory. <sup>15,16</sup> Systematic review level evidence<sup>17,18</sup> has demonstrated that regular self-weighing (SW) has been consistently associated with weight loss, and Shieh *et al.*<sup>19</sup> reported that higher SW frequency is associated with better weight outcomes and achieving 5% weight loss. Current NICE guidelines (2014)<sup>20</sup> recommend that adults include self-monitoring of behaviour and progress in behavioural interventions for weight management.

The current work employs a novel approach in that volunteer (lay) coaches provide telephone delivered, personalised, support and feedback on self-management of weight. This approach builds more generally on using HND

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a community assets approach to complement NHS services.

The aim of the current work was to examine the response to the weight self- awareness plan (used as part of the ActWELL multi-component weight management intervention programme) among older women with excess weight who participated in the RCT. Specifically, we examined how far participants engaged with the plan, what socio-demographic factors were associated with greatest participation in SW, the relationship between weight awareness and weight management, and participants' views on monitoring body weight.

### METHODS

The ActWELL trial recruited 560 women, aged 50–70 years with BMI > 25 kg m<sup>-2</sup>,<sup>12</sup> via invitation cards which were provided at routine breast screening clinics. Respondents who completed the cards were contacted by telephone on a 'first come, first served' basis. Those who met eligibility criteria on a telephone screening call were then invited to attend their local research centre to provide informed consent and commence baseline measures prior to randomisation using the web-based TRuST system developed and managed by the Tayside Clinical Trials Unit.<sup>10</sup>

# Initiating weight loss awareness procedures (intervention group only)

All ActWELL trial participants (n = 560) had their body height and weight measured at baseline and 12 months by research nurses at clinical research centres. For intervention participants volunteer LCs showed intervention participants (n = 279) how to assess their BMI  $(\text{kg m}^{-2})$  (based on measured height and weight, which were recorded in research centres and made available to LCs), aiming to identify participant weight category (overweight or obese). Weight loss goals (in kg) were then set to attain a reduction in 7% of body weight over the 12-month intervention period. In addition, it was noted that if weight loss targets were achieved, guidance for weight loss maintenance would be provided. The control group received no advice regarding weight measurement. Full details of recruitment, randomisation, analysis and results of the ActWELL trial are presented elsewhere.<sup>12</sup>

### WAP (intervention group only)

The WAP was also introduced to participants at the first intervention session. To help support weekly SW procedures, LCs invited intervention participants to undertake an implementation intention<sup>21</sup> discussion.

Participants were asked to identify where and when they would weigh themselves, who would support them in their task (action plans), potential barriers that might arise and how these could be addressed (coping plans). Guidance was provided on weighing in a consistent manner (day, time, place) thus helping to establish a routine/habit and to minimise recording on within-day weight fluctuations. Digital bodyweight scales were offered and record books for recording weekly weights were provided. Participants were then advised that LCs would contact them by telephone at monthly intervals and provide feedback and discussion on all weekly weight recordings, weight change and general progress on diet and physical activity (no pedometer collected step counts were collected). Notes on reported weight records and feedback provided were kept in coach logbooks for coaching purposes.

### **Evaluation procedures**

### Quantitative measures

Background characteristics collected at research centres were obtained from the trial database. The key variables used for analysis were age, ethnicity, socio-economic indicators (Scottish Index of Multiple Deprivation; SIMD),<sup>22</sup> education (highest level) and home ownership status.

Coach logbooks were used to assess the number of participants who utilised implementation intention plans and the frequency with which participants disclosed their self-weights to LCs. Participants were asked to record their weight following SW. The maximum number of participants' weights logged from the WAP telephone calls was nine (i.e., one per monthly telephone call). It was assumed that if a participant declined to inform their coach of their current weight and that either SW had not been undertaken or they did not wish to report the results, either way they did not comply with the WAP. To better assess differential outcomes, participants were divided into frequent or less frequent recorders by the mean number of weight records attained in the group.

### Qualitative interviews

To assess the overall acceptability of the ActWELL programme, qualitative evaluation researchers (MS and JM) undertook telephone interviews with intervention participants which followed a semi-structured topic guide. The topic guide was informed by the research objectives and by previous work conducted by the investigators exploring engagement with lifestyle interventions.<sup>23</sup>

All participants were asked if they would like to take part in these interviews after the final data collection for the RCT was complete. Six interviews per service area that participated in the trial were sought, from areas of both high and low deprivation quintiles (identified by SIMD). Twenty-four participants of 26 approached for interview agreed to participate. Most participants (80%) were from higher SIMD quintiles 3, 4 and 5 (less deprived), which was consistent with overall response rates.

With the consent of the participant, interviews were audio-recorded and transcribed verbatim and lasted on average a little under an hour. Participants were asked about their views on and experiences of different aspects of the trial design, delivery and content, including the WAP (SW, recording and telephone feedback). For the interview topic guide, see the Appendix

### Statistical analysis

Quantitative: Those missing either baseline or 12 months weight data were excluded. Univariate analysis was performed using demographic data and participant weight change. Chi-squared tests were performed to examine the effect of SW frequency on weight change, BMI change and percent weight loss. Mann–Whitney test were used to compare median weight lost by participants who engaged or did not engage with the WAP. Analyses were conducted using SPSS, version 25 (IBM Corp.).

Qualitative: Interview transcripts were analysed thematically. Analysis began with MS reading a sample of six transcripts and producing a draft coding framework. JM undertook test coding of four transcripts using the draft framework. Once complete, MS and JM agreed a second, finalised coding framework which was applied to the full set of transcripts as facilitated by qualitative data analysis software (NVivo 12; QSR International). The finalised framework included 14 themes, with 12 of these including sub-themes ranging in number from 2 to 11. Most of the themes included in the framework were deductive, such that they were informed by the topic guide, with a smaller number of inductive themes, arising from interviews. Themes identified from interviews were included if data relevant to these were mentioned by a substantial proportion of interviewees. Analytical procedures took account of the overall intervention methods including COM-B components.9 Participant views on the WAP reported here were drawn from data coded under the sub-theme: 'Weighing self regularly', under the main theme of 'Monitoring and ActWELL documentation'.

### RESULTS

In total, 560 women were enrolled in the study of whon 279 were randomised to the ActWELL intervention arm. At 12 months, 226 (81%) returned for follow-up measures of the

primary outcome. One participant was excluded from the final analysis because of absence of baseline body weight; therefore, 225 participant data were utilised. For those who completed the study, most (90%) participants attended both face-to-face consultations and 59% completed all nine planned telephone calls.

In total, 24 women participated in semi structured interviews and useable data was available from all of these.

The mean age at baseline was 58.8 years, which reflects the screening policy of inviting women aged 50–70 years for routine mammography. Participants came from all socioeconomic groups; 16% were from SIMD 1 and 2 (highest areas of social deprivation). The majority were well educated and in paid employment. The mean  $\pm$  SD BMI of the group at baseline was 31.0  $\pm$  4.7 kg m<sup>-2</sup>. Intervention group participants who completed the study were similar in age and other socio-demographic characteristics to all trial participants (Table 1).<sup>12</sup>

### **Engagement with WAP**

Overall initiation of goal setting to self-weigh weekly and report weights at monthly intervals was high (Table 2). Of the participants who enrolled on the study, 76 (27%) requested a set of digital bodyweight scales. For those who completed the trial, 93.8% self-reported their weights (at least once) to LCs. The mean  $\pm$  SD number of times that participants self-reported their weight during telephone calls with the LC was 7  $\pm$  2.7.

No differences were detected in socio-economic markers (ethnicity, SIMD, education level, employment and home ownership status) between those who were below and above the mean frequency (n = 7) of SW (Table 3).

# Relationship between weight awareness and weight management

The median (interquartile range) weight loss (-2.3 kg; -5.0 to 0.0) for those who engaged in weight recording (n = 211; self-weighed at least once) was greater than those (n = 14) who did not engage in any SW (-1.2 kg; -5.0 to 0.03; p > 0.05, not significant). Participants who self-weighed most (8–9 times) were significantly more likely to achieve 3% ( $\chi^2$  [d.f. = 1, n = 225] = 11.542, p = 0.001) and 5% ( $X^2$  [d.f. = 1, n = 225] = 6.321, p = 0.012) weight loss compared to those who weighed less often (Table 4).

# Participants' views on weight awareness procedures

### SW and recording

Views on the acceptability of SW varied. Many participants reported being content to weigh themselves

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TABLE 1	Socio-demographic characteristics of intervention
participants	at baseline and completion

	All ( <i>n</i> = 279)	Completed ( <i>n</i> = 225)	p value
Age (years), mean (SD)	58.8 (5.2)	59.1 (5.3)	0.549
Ethnicity, N (%)			0.259
White	273 (97.8)	223 (99.1)	-
Asian/Asian British/ mixed	6 (2.2)	2 (0.9)	-
SIMD quintile, $N$ (%)			0.916
1 (most deprived)	21 (7.5)	13 (5.8)	_
2	25 (9.0)	21 (9.3)	-
3	38 (13.6)	26 (11.6)	
4	65 (23.3)	53 (23.6)	-
5 (least deprived)	128 (45.9)	111 (49.3)	_
Unknown	2 (0.7)	1 (0.4)	_
Education, highest level, N	r (%)		0.954
Secondary	57 (20.4)	44 (19.6)	-
Other professional/ technical qualification	90 (32.3)	75 (33.3)	-
University degree	132 (47.3)	106 (47.1)	-
Employment, $N$ (%)			0.902
Retired	90 (32.3)	73 (32.4)	-
Unemployed	2 (0.7)	2 (0.9)	-
Employed, full-time	91 (32.6)	63 (28)	
Employed, part-time	71 (25.4)	63 (28)	_
Student, full-time	2 (0.7)	2 (0.9)	_
Other	23 (8.2)	22 (9.8)	_
Home status, $N$ (%)			0.323
Owner occupied	255 (91.4)	209 (92.9)	_
Rented	24 (8.6)	16 (7.1)	-

Abbreviations: SIMD, Scottish Index of Multiple Deprivation.

on a regular basis, with some mentioning that they had been used to monitoring their weight regularly. Although some found the task helpful and motivating, others felt that checking their weight could be demotivating.

> ... keeping a wee note of your weight was quite a good wee monitor. A wee jag to keep you going (Participant A, Service 1)

> I wasn't too happy when I hadn't lost anything. Even a pound or so was fine. No, it was just pack (sic) and parcel of the whole deal. It was quite good looking at the chart

All ( <i>n</i> = 279)	Completed trial ( <i>n</i> = 225)						
269 (96.4%)	218 (96.9%)						
10 (3.6%)	7 (3.1%)						
279 (100%)	225 (100%)						
Self-reported weights given to coaches at monthly calls (at least once)							
248 (88.9%)	211 (93.8%)						
31 (11.1%)	14 (6.2%)						
279 (100%)	225 (100%)						
	All ( <i>n</i> = 279) 269 (96.4%) 10 (3.6%) 279 (100%) coaches at monthly ca 248 (88.9%) 31 (11.1%) 279 (100%)						

at the very beginning, and when you were getting to a certain stage you thought, god, how many pounds is that. It was really good ... (Participant F, Service 2)

I'm not a great one for getting on the scales, because I think I tend to go by my clothes and I know if I've put on a bit or I've lost a bit or whatever, so I tend ... I don't like to stand on the scales. I think that can be a bit of a demotivator, for me anyway. I know that there's other people like to stand on the scales every single day, which is ridiculous. So for me I know how I feel about myself and about my body (Participant G, Service 3)

Some participants mentioned that they did not have access to a set of weighing scales or one that was accurate and were pleased to have received a set from the LCs.

> [LC's coach] gave me the use of a set of scales, so that was good, because I didn't have any scales. That was good to have accurate scales (Participant B, Service 2)

### Telephone feedback

Participants generally welcomed the regular phone calls from LCs to discuss progress with regard to their goals (although there was an overall preference for face-to-face communication during the intervention). LCs were perceived as motivating and non-judgmental, providing praise for success and encouragement when setbacks were experienced.

As I say, I had a good rapport with [LC] so I actually looked forward to them (phone calls). I was never – even if I'd put on

	SW 0–7 times ( <i>n</i> = 72)	SW 8–9 times ( <i>n</i> = 153)	p value
Age in years, mean (SD)	58.6 (5.5)	59.2 (5.2)	0.429
Ethnicity, N (%)			0.584
White	71 (98.6)	152 (99.3)	-
Asian/Asian British/ mixed	1 (1.4)	1 (0.7)	-
SIMD quintile, N (%)			0.421
1 (most deprived)	5 (6.9)	8 (5.2)	-
2	7 (9.7)	14 (9.2)	-
3	7 (9.7)	19 (12.4)	-
4	21 (29.2)	32 (20.9)	-
5 (least deprived)	31 (43.1)	80 (52.3)	-
Unknown	1 (1.4)	0 (0)	_
Education, highest level, N	(%)		0.496
Secondary	11 (15.3)	33 (21.6)	-
Other professional/ technical qualification	24 (33.3)	51 (33.3)	-
University degree	37 (51.4)	69 (45.1)	-
Employment, N (%)			0.076
Retired	21 (29.2)	52 (34)	_
Unemployed	0 (0)	2 (1.3)	_
Employed, full-time	29 (40.3)	34 (22.2)	_
Employed, part-time	17 (23.6)	46 (30.1)	_
Student, full-time	1 (1.4)	1 (0.7)	_
Other	4 (5.5)	18 (11.8)	-
Home status, $N$ (%)			0.949
Owner occupied	67 (93.1)	142 (92.8)	-
Rented	5 (6.9)	11 (7.2)	_

**TABLE 3** Socio-demographic characteristics of participants by frequency of reported self-weighing (SW) (mean = 7)

**TABLE 4**Relationship betweenfrequency of self-reported weighing andpersonalised weight loss goals

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(weight), I didn't feel, oh god, here we go. I never felt under pressure. I never felt under pressure at all with the phone calls or anything (Participant D, Service 1)

She would say oh you've lost two pounds this week, or you've lost four pounds in a fortnight. You're doing well, blah, blah, blah. So that kind of spurs you on (Participant C, Service 1)

Participants also felt that the prospect of receiving calls was helpful in motivating them to keep going with the changes they had made due to a desire to want to demonstrate progress. In this context, SW, and the associated accountability of reporting it to someone else, was often key to this process.

> And it, kind of, got you motivated 'cause you knew that she was going to phone you and you knew that you had to behave, if you like, before she phoned. 'Cause you wanted ... you desperately wanted this weight when you ... when she phoned, you desperately wanted to tell her that your weight was down ... I don't know if 'checking up on you' is the right word or not, but ... or being, you know ... phoning you to keep an eye on you or whatever, however you want to word it, it does, sort of, give you incentive to not put that biscuit in your mouth. To make sure ... you know, even if it is raining, go out for your walk or whatever (Participant C, Service 4)

> It's something (weighing self) I really needed to do. It was like a little bit of incentive you know, thinking I'm going to have to write down my weight and I'm going to have to tell them and I don't want to be going in the wrong direction. So it was just a help. You just don't feel as if you're on your own with it (Participant B, Service 1)

	n	Met 3% WL goal	Did not meet 3% WL goal	Met 5% WL goal	Did not meet 5% WL goal
SW frequency 0–7 times	72	23	49	16	56
		(31.9%)	(68.1%)	(22.2%)	(77.8%)
SW frequency 8–9 times	153	86	67	60	93
		(56.2%)	(43.8%)	(39.2%)	(60.8%)

Abbreviation: SW, self-weighing; WL, weight loss.
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... don't get me wrong, I have fallen off the bandwagon several times in a spectacular way but I was always aware that [LCs] would be phoning me and I would have to get back onto the bandwagon (Participant E, Service 4)

However, a few participants expressed some dissatisfaction with the phone calls, feeling that there was a lack of rapport and limited value in the contact with the coach when it was not in person. Instead, face-to-face contact fostered a greater feeling of accountability.

> I had the phone calls and I just felt I could be saying anything to the lady over the phone, you know, like oh yes, I'm walking, I'm doing this, I'm doing that. She really had to believe what I was saying (Participant G, Service 4)

### DISCUSSION

The results indicate that the WAP used within a 12-month, multi-component weight management intervention was successfully initiated and supported by LCs. For women who attended both the ActWELL baseline and 12-month measurement visits, engagement with the WAP was associated with a greater likelihood of achieving up to 5% weight loss and was acceptable to participants.

The strength of the present study includes the novel delivery of a WAP programme which was informed by the COM-B framework and aimed to improve capability for weighing by offering scales (which a notable 27%) accepted), opportunity for recording and receiving feedback, and motivation through the use of implementation intentions, action and coping planning and LC contact and support. Efforts were made to avoid potential inequality issues by offering free scales, minimising recording procedures and utilising coach-initiated feedback. Qualitative data suggests that participants were generally satisfied with the number, frequency and timing of LC calls, which is supported by the high numbers (211 of 225; 93.8%) undertaking the WAP procedures and that these helped participants to feel accountable, receive neutral feedback and maintain motivation. However, the WAP used in the present study was not tested as a single intervention and thus it is not possible to estimate the effect size of the WAP per se because it is likely that other programme features (e.g., personalised advice, social support) contributed to the weight loss achieved by the intervention group.

Qualitative results suggest that not all participants appreciated SW, but it is not possible to identify whether this may have been a reason for study drop out in the 19% who failed to complete the ActWELL trial. Not knowing the 12-month weight of these participants, and therefore being unable to include them in the present study, is a limitation. The number of participants who provided a 12-month measurement but did no SW is small (14 of 225), which does suggest that women who did not self-weigh may have been more prone to miss the 12-month measurement. These 14 women lost less weight than the SW majority and, perhaps, had we had 12-month data from all women, our confidence in this result would be stronger. As it is, uncertainty about the 12-month weight of the 19% of women who failed to complete the trial remains and is of course a limitation and an interesting area to explore in future studies.

Our findings agree with systematic review findings by Shieh et al.<sup>19</sup> in that higher SW frequency is associated with better weight outcomes and achieving 5% weight loss. Both daily and weekly SW are associated with positive weight management outcomes, but weekly approaches reduce participant burden. There is evidence to support the beneficial role of successful weight loss with higher frequencies of SW in females in their fifth and sixth decade of life when SW of body weight is the primary intervention.<sup>24-26</sup> Yet, successful weight loss is likely to be achieved as part of a multi-faceted behaviour change approach, involving not only self-monitoring, but also strategies such as goal setting and changing beliefs and expectations. Similarly, weight monitoring is likely to be beneficial in weight loss maintenance<sup>27,28</sup> although it is unclear how useful this is after feedback is no longer available.

Overall, the findings of the current work suggest that the novel approach of delivering the intervention including the WAP by volunteer LCs is a useful tool in the portfolio of weight management techniques. It is not clear whether the feedback from coaches motivated adherence (and therefore continued weight loss) or whether participants who were already adhering well were more likely to report to coaches. In the current context of women attending routine breast screening clinics, the WAP offers a starting point for raising awareness of excess body weight and a prompt for weight management action. Whether self-reporting would be an accurate record of weight change (when no independent body weight measurements are made for comparison) is unknown, although recent developments in smart scale technology could assist in increasing validity<sup>29,30</sup>

Further work is needed to explore the long-term usage of the WAP programme in the intervention group, factors that have influenced its continuation and continuing weight trajectories, particularly weight loss maintenance.<sup>31</sup> Further work could also explore the potential of feedback on step count recording, which could help participants achieve greater physical activity (no significant difference in step count was achieved in the RCT.<sup>12</sup>

In conclusion, a WAP initiated by volunteer LCs as a part of a multi-component weight loss intervention is

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generally acceptable to users and greater frequency of weight reporting is likely to be associated with achieving 5% weight loss.

#### AUTHOR CONTRIBUTIONS

Suzanne M. M. Zaremba: Research concept and design, data analysis, drafting publication. Martine Stead: Research concept, interview design, interviewing, qualitative analysis, drafting publication. Jennifer McKell: Research concept, interview design, interviewing, qualitative analysis, drafting publication. Nanette Mutrie: Research concept and design, data collection design, guidance on analysis and interpretation of physical activity. Ronan E. O'Carroll: Research concept and design, guidance on psychological concepts, interpretation, drafting publication. Shaun Treweek: Research concept and design, data collection design, data interpretation, drafting publication. Annie S. Anderson: Research concept and design, data collection design, interview design, data interpretation, drafting 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 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 protocol for the ActWELL study was approved by East of Scotland Research Ethics Committee (17/ES/0073). All participants provided written informed consent for data analysis before participation.

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# APPENDIX

ActWELL Participant Exit Interview Topic Guide Introduction

Personal introduction followed by explanation of purpose of interview and focus upon experience of ActWELL study. Emphasise researcher independence from study team and counsellors and encourage expression of candid thoughts and opinions. Check for any questions from participant. Introduce voice recorder and check that participant is comfortable with use of voice recorder.

- 1. Background lead in as appropriate
  - Age; place of residence; family circumstances
  - Current general health
- 2. Introduction to study (and expression of interest)
  - How first became aware of ActWELL study? recall of discussion with mammography staff were they encouraging or neutral?
  - Initial thoughts/responses to the study
  - · Reasons for expressing interest in participation
  - Recall of receiving study information and any letter of endorsement from lead doctors (local area)
- 3. Study team contact; deciding to take part and recruitment to the study
  - Recall of first contact with study team a week after clinic appointment (by email or by phone?)
    - Impressions of researcher
    - Understanding of process proposed
    - Any queries/concerns
    - Thoughts on collection of all measurement data including height and weight data was it too much
    - Was the follow up visit helpful/acceptable
  - Recall of receiving full study information sheet and sufficiency and clarity of information
  - Thoughts on provision on opt-out slip and prospective appointment
  - Thinking about taking part in study and discussion with others: friends/family; professionals/study team (opportunity to ask questions?)
  - Factors encouraging participation; for example, a desire to help; to feel fitter/healthier
  - Factors discouraging participation; for example, time and practicalities involved
  - · Final reasons balance of decisions for taking part
  - Previous experience of lifestyle change
  - Attending study centre
    - Ease/cost of attendance with relative/friend
    - Duration/timeliness of appointment
    - Coverage of issues/queries answered
    - Thoughts on collection of baseline measurements by staff
    - Perspective of staff conducting appointment
    - Thoughts on inclusion of formal consent procedure at this stage
    - Thoughts on the randomisation process

- Expectations and understanding of what the study would entail: any remaining concerns or anxieties
- 4. Face to face appointment with lifestyle coach (× 2 in leisure centre/community setting)
  - Any expectations prior to attending the appointments
  - Recall of appointment including when it took place, with whom and duration (sufficient?)
  - Thoughts on approach and manner of coach (check what language they use to describe the coaches title/role)
  - How they felt about the idea of changing diet and activity
  - Any goals set

# 5. Phone-calls (up to 9 over period of 12 months)

- How well did conversations with the counsellor work on the phone comparison with face-to-face contact
- Any issues around fixing up times for calls, privacy, convenience and so on
- Probe recall of what was discussed in each call, what advice the counsellor gave; any changes in the calls as months progressed (e.g., more cursory/ more in-depth)
- Progress towards meeting goals, sticking to plans, any setbacks and impact and so on

# 6. Info and advice given (also use of pedometer)

- Recall of information, tips and strategies suggested by the counsellor concerning:
  - Diet: substitution of foods (e.g., brown rice for white), portion size and control, calorie control, cooking methods, snacks and so on
  - Weight loss: target amount, frequency of weighing self
  - Physical activity: steps or other targets, frequency of activity, type of activity, substitution/ incorporation into everyday life (e.g., walking the longer way back from the shops) and so on
- Usefulness of pedometer and associated walking programme
- Usefulness of ActWELL information pack

# 7. General aspects of participation (if not already covered above)

- Experience of monitoring
  - Weighing self
  - Collection of follow up measurements
- Overall understanding of the programme and objectives
  - Understanding purpose of different aspects: exercise, weight loss, diet changes
  - Goal setting how decided, perspectives including understanding of expectations
- Changes made in terms of exercise, weight and diet
- Any barriers to making changes
- Any facilitators to making changes
- Ability and success in maintaining changes
- Satisfaction or otherwise with progress made

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• What if anything they would do differently if participating in the programme again

• Other

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# 8. Social support

- Perceived response (encouragement, support and so on) from
  - Family, especially those living in same home
  - Friends

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Others; for example, professionals, such as GPs
Wider community context (if not already covered above): how easy is it to make changes to diet in terms of what's available in the local food shops/ the sorts of food you can afford; how easy is it to do

more physical activity living here/given your lifestyle and ability?

# 9. Overview

Whether breast screening clinics are acceptable/feasible setting for recruitment into a lifestyle intervention

Initial expectations match experience of taking part? Advantages

Disadvantages

What parts liked least/liked most

Any parts of the programme that could be improved Whether would recommend or discourage others to take part in programme

Other

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#### PRINCIPLES OF NUTRITION AND DIETETICS

# Effect of vitamin D<sub>3</sub> supplementation on cardiometabolic disease risk among overweight/obese adult males in the UK: A pilot randomised controlled trial

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**Background:** Observational studies suggest links between reduced serum 25(OH)D concentration and increased cardiometabolic disease risk. However, these studies provide limited evidence of causation, with few conclusive randomised controlled trials (RCT) having been carried out to date. This RCT investigated the effect of vitamin D<sub>3</sub> supplementation on vascular function and cardiometabolic disease risk markers, in 55 healthy males aged 18–65 years with plasma 25(OH)D concentration <75 mol L<sup>-1</sup> and body mass index  $\geq$ 24.9 kg m<sup>-2</sup>.

*HND* 

**Methods:** Participants were assigned to consume  $125 \ \mu g \ day^{-1}$  (5000 IU  $day^{-1}$ ) vitamin D<sub>3</sub> or placebo for 8 weeks. Blood samples and vascular function measures were obtained at baseline, as well as at weeks 4 and 8. The primary outcome was arterial stiffness, an indicator of cardiovascular disease (CVD) risk, assessed by pulse wave velocity. Biomarkers of CVD risk, insulin resistance and endothelial function were measured using an enzyme-linked immunosorbent assay.

**Results:** Daily oral intake of  $125 \,\mu\text{g}$  supplemental vitamin D<sub>3</sub> led to a significant improvement in plasma 25(OH)D concentrations over the 8-week intervention in the vitamin D group compared to the change in the placebo group (p < 0.001). In the vitamin D group, the baseline mean  $\pm$  SD 25(OH)D concentration was  $38.4 \pm 15.9$  and this increased to  $72.8 \pm 16.1 \,\text{nmol L}^{-1}$  after 8 weeks of supplementation. The intervention had no effect on arterial stiffness, as measured by pulse wave velocity, although vitamin D<sub>3</sub> supplementation did lead to a decrease in mean  $\pm$  SD brachial pulse pressure from baseline to 8 weeks of  $-2.9 \pm 3.4 \,\text{mmHg}$  (p = 0.027) in the vitamin D group compared to the same period in the placebo group. The intervention had no effect on the remaining cardiometabolic parameters.

**Conclusions:** Overall, treatment significantly improved brachial pulse pressure but no other cardiometabolic disease risk markers. To follow on from this pilot RCT, future large-scale clinical trials over longer durations may offer further insights.

#### **KEYWORDS**

cardiometabolic disease, endothelial function, inflammation, obesity, randomised, vitamin D<sub>3</sub>

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### Key points

- This pilot randomised controlled trial investigated the effect of vitamin  $D_3$  on arterial stiffness, biomarkers of cardiovascular disease risk and insulin resistance in vitamin D insufficient overweight and obese adult males.
- Supplementation significantly decreased brachial pulse pressure in the vitamin  $D_3$  group at 4 and 8 weeks but did not improve the other cardiometabolic markers measured.
- The findings from the present study are in agreement with previous research that does not support the use of daily high-dose vitamin D supplements for the purpose of reducing risk of cardiovascular disease.

# INTRODUCTION

Observational studies have described correlations between vitamin D deficiency as indicated by low serum 25(OH)D status and cardiometabolic disease risk factors,<sup>1,2</sup> including endothelial dysfunction,<sup>3</sup> inflammation,<sup>4</sup> insulin resistance,<sup>5</sup> hypertension,<sup>6</sup> dyslipidaemia,<sup>7</sup> oxidative stress<sup>8</sup> and arterial stiffness.<sup>9</sup> These relationships are supported by evidence which shows that many pathways and cell types implicated in cardiovascular disease (CVD) pathogenesis are regulated through vitamin D metabolites because most cardiovascular and inflammatory cells express vitamin D receptor (VDR) and CYP27B1, a mitochondrial 1 $\alpha$ -hydroxylase enzyme that catalyses the conversion of inactive vitamin D to its active form.<sup>10</sup>

For beneficial extra-skeletal outcomes, Bischoff-Ferrari suggested improving serum concentrations of 25(OH)D to 75–100 nmol  $L^{-1}$ .<sup>11</sup> However, much of this evidence is established by observational studies that are unable to provide strong evidence of causality. The limited number of randomised controlled trials (RCT) evaluating the effect of supplemental vitamin D on cardiometabolic disease risk factors, particularly endothelial function and arterial stiffness in various human populations, are inconsistent. A metanalysis of 81 RCTs found that vitamin D supplementation significantly reduced systolic and diastolic blood pressure (SBP and DBP), high-sensitivity C-reactive protein (hs-CRP) total cholesterol (TC) low-density lipoprotein cholesterol (LDL-C), triacylglycerols (TAG) and significantly increased high-density lipoprotein cholesterol (HDL-C), but did not significantly impact arterial stiffness parameters.<sup>11</sup> Some of the studies included in this meta-analysis, recorded significant reductions in SBP and DBP following vitamin D supplementation, in overweight and obese participants, who are the target group in our study. However, the number of studies investigating arterial stiffness measures were limited and inconclusive, indicating a need to carry out further studies incorporating arterial stiffness measures. Additionally, some of the studies included in the meta-analysis administered vitamin D along with calcium, which is a confounding factor. Furthermore, participants of some of these RCTs were older, with already established

cardiovascular disease.<sup>12</sup> However, in contrast to these findings, meta-analyses of  $RCTs^{13,14}$  and further individual vitamin D supplementation studies<sup>15–17</sup> did not provide conclusive evidence on the beneficial effects of vitamin D on cardiovascular outcomes.

The possible mechanisms by which optimal vitamin D influences vasoprotection may be stimulation of the production of endothelial nitric oxide,<sup>18</sup> downregulation of the renin–angiotensin system<sup>19</sup> and modulation of the inflammatory processes and lipid metabolism.<sup>20</sup> Vitamin D may also directly regulate vascular smooth muscle cell production<sup>21</sup> and inhibit the harmful effects of advanced glycation end-products on vascular ageing.<sup>22</sup>

In addition to low serum 25(OH)D concentrations, adiposity has been implicated in the pathogenesis of cardiometabolic disease risk.<sup>23</sup> Inverse associations have been described between low serum  $25(OH)D_3$  and adiposity, possibly as a result of the dilution of ingested or cutaneously synthesised vitamin D in the enlarged fat mass.<sup>24</sup>

Inconsistent findings have been reported by RCTs evaluating the effect of supplemental vitamin D on cardiometabolic risk, and these trials were often powered on non-cardiometabolic outcomes. The aim of this pilot RCT was to investigate the effect of a daily oral intake of 125  $\mu$ g of vitamin D<sub>3</sub> on haemodynamic measures, including arterial stiffness, insulin resistance and biomarkers of CVD risk in vitamin D-insufficient overweight and obese adult males.

# **METHODS**

# Study population

Healthy overweight/obese adult males aged 18–65 years with body mass index (BMI)  $\ge 24.9$  kg m<sup>-2</sup> and plasma 25(OH)D concentration <75 nmol L<sup>-1</sup> were recruited using study posters/leaflets and newspaper advertisements. The threshold was selected as 75 nmol L<sup>-1</sup> and was regarded as the upper threshold for insufficiency.<sup>25</sup> Participants were excluded if they had previously been clinically diagnosed with cardiometabolic, renal, liver or

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gastrointestinal disease and were taking supplemental vitamin D. Participants provided written informed consent, and trial was performed in accordance with the Helsinki Declaration.<sup>26</sup> Consolidated Standards of Reporting Trials (CONSORT) were also followed.<sup>27</sup> Ethical approval was obtained from the University of Chester Faculty Research Ethics Committee (REF: 855/13/AT/CSN) and the trial was registered at clinicaltrials. gov (NCT02359214). The study was conducted from November 2014 to May 2015 and from October 2015 to January 2016 aiming to reduce the impact of UVB radiation exposure from the sun. Although four participants finished in early May 2015, their final vitamin D concentration was not significantly different from the overall group.

#### Study design

The trial was a randomised, double-blinded and placebo-controlled. Participants were randomly allocated to an 8-week intervention with oral vitamin  $D_3$ supplements, containing 125 µg of cholecalciferol, calcium phosphate, microcrystalline cellulose, magnesium stearate and silica or a placebo containing lactose taken daily. The dose of  $125 \,\mu g \, day^{-1}$  (5000 IU  $day^{-1}$ ) of vitamin D<sub>3</sub> was selected because it was shown to increase plasma 25(OH)D levels by approximately 220% in a 12-week intervention in 30 patients with serum  $25(OH)D \leq 50 \text{ nmol } L^{-1}$ , with a mean postintervention plasma 25(OH)D concentration of  $114.4 \pm 22.2$  nmol L<sup>-1</sup>.<sup>28</sup> Although the present RCT duration is 8 weeks, the post-intervention value from the study is significantly higher than the optimal threshold of 75 nmol  $L^{-1}$ , and a significant increase was thus deemed achievable in the 8-week timeframe of the present study. The dose used in the present study has been safely used in previous intervention studies (including pregnant women) and it has been shown to significantly increase serum/plasma 25(OH)D concentration.<sup>28</sup> Vitamin  $D_3$  and placebo tablets were purchased from Bulk Powders and Placebo-world, respectively, and were indistinguishable for blinding purposes. The investigator, participants and research staff were blinded to study allocation until the trial was completed. A third party assigned the participants to either the vitamin  $D_3$  or the placebo group by means of a computer-generated random number sequence (www. randomization.com). Block randomisation was utilised to ensure balance in sample size across the groups. The third party was also responsible for packaging tablets into tamper-proof containers, and sealing them in sequentially numbered study packs.

Compliance was estimated by counting unused tablets in the containers at the conclusion of study using: % compliance = (actual/expected) × 100.

### **Dietary intake**

Participants' dietary intake over three successive days (2 weekdays and 1 weekend day) was evaluated using a 3-day food diary and was completed at baseline and the final week of the study (week 8). Food and drink intake between meals or at night were noted. Participants recorded all fortified foods, and for homemade dishes, the recipe, quantity of ingredients and cooking method were documented in the diary. Mean daily energy, protein, fat, carbohydrate and vitamin D intake were assessed using dietary analysis software (Nutritics, version 4.25; Nutritics).<sup>29</sup>

#### Measurements

All participants at the screening clinic, received a participant information sheet, and were asked to complete a screening questionnaire as well as an informed consent document. Participants' BMI was obtained by measuring weight and height using calibrated scales and a stadiometer. To confirm eligibility, 1 ml of blood drawn from the median cubital vein was used to assess vitamin D status. Participants with plasma 25(OH)D concentrations below 75 nmol/L were invited to take part in the study. At baseline, as well as the 4- and 8-week clinics, following an overnight fast, venous blood samples were collected from each participant to assay 25(OH)D, parathyroid hormone (PTH), LDL-C, HDL-C, TC, non-HDL-C, TAG, hs-CRP, sE-selectin, renin, angiotensin II, glucose, insulin and 8-isoprostane concentrations. To avoid clotting, venous blood was drawn with a 21-gauge vacutainer needle into sterile 10-ml lithium heparin and EDTA tubes and stored at 4°C. Plasma was separated by centrifuging whole blood for 10 min at 4°C at 2054 g and aliquoted into microcentrifuge tubes and stored at -80°C until batch analysis, with the exception of the screening clinic samples, for which 25(OH)D concentrations were determined within 24 h, aiming to ascertain whether the participant was eligible for the study. Overall, participants attended four clinics (screening, baseline, weeks 4 and 8).

# Measurement of plasma vitamin D concentration

Plasma concentration of 25(OH)D was measured with a VIDAS<sup>®</sup> 25(OH)D total assay kit (BioMérieux), which applies the enzyme linked fluorescent assay method on the mini VIDAS<sup>®</sup> automated immunoassay-analyser. The intra- and interassay coefficients of variation (CV) were 2.0% and 7.3%, respectively. For plasma samples with lower 25(OH)D concentrations (below 20.3 nmol L<sup>-1</sup>) that the automated immuno-analyser was unable to detect, an

enzyme-linked immunosorbent assay (ELISA) (Calbio-tech) was used.

### **Biomarkers**

Plasma sE-selectin (collected in heparin tubes) and renin concentration were assessed using ELISA kits (R&D Systems Europe). Intra- and interassay CV for plasma sE-selectin and renin concentration were 3.4% and 3.4% and 8.9 % and 5.3%, respectively. Plasma PTH, hs-CRP and insulin concentrations were determined using an ELISA (Calbiotech). Intra- and interassay CV were 4.7% and 2.6%; 6.0% and 2.3%; and 3.4% and 8.9%, respectively. Plasma glucose and TC concentrations were measured by means of a colorimetric enzyme reagent kit (Alpha Laboratories). Intra- and interassay CV for plasma glucose and TC were 3.0% and 5.3% and 5.2% and 6.4%, respectively. The plasma 8-isoprostane concentration was determined using a competitive in vitro ELISA (Abcam). The intra- and interassay CV was 5.9% and 11.1%, respectively. Plasma TAG was measured using a quantitative enzymatic TAG determination kit (TRO100; Sigma-Aldrich). HDL-C was determined using a HDL quantitation kit in which HDL is first precipitated and then the cholesterol concentration is determined by a coupled enzyme assay, resulting in a colorimetric product (MAK045-1KT; Sigma-Aldrich). Plasma, angiotensin II concentration were determined using a competitive enzyme immunoassay kit (RAB0010; Sigma-Aldrich). Intra- and interassay CV for TAG, HDL-C and angiotensin II were 2.6% and 6.2%; 3.4% and 8.1%; and 9.5% and 8.9%, respectively.

LDL-C concentration was determined by means of the Friedewald formula<sup>30</sup>:

Plasma LDL-C = Plasma TC – Plasma HDL-C – (TRG/2.2).

Non-HDL-C concentration was determined using: non-HDL-C = TC – HDL-C.

Insulin resistance and homeostasis model assessment of insulin resistance (HOMA-IR) was using: HOMA-IR = (fasting plasma glucose concentration (mmol  $L^{-1}$ ) × fasting plasma insulin concentration (mU  $L^{-1}$ )/ 22.5.<sup>31</sup>

#### Arterial stiffness

Prior to fasted venous blood samples being drawn at baseline, as well as 4- and 8-week clinics, measurement of arterial function parameters was carried out in a quiet room at  $22 \pm 1$ °C, with the participant consuming a glass of water and then lying in a supine position for 10 min before a cuff was placed firmly around the right arm. Arterial function parameters determined, include aortic pulse wave velocity (PWVao), brachial and aortic augmentation indices (AIx), central systolic blood

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pressure (SBPao), return time of aortic pulse wave (RTao), SBP and DBP, heart rate (HR), mean arterial pressure (MAP), brachial pulse pressure (PP) and central aortic pulse pressure (PPao), using a non-invasive clinically validated automatic oscillometric device (Arteriograph 5-01, version 1.9; TensioMed). Aortic distance was obtained as the distance between jugular notch and symphysis pubis (Jug-Sy) using a measuring tape with participant standing upright. For each participant, three measurements, each lasting 2-3 min were performed with the average of the last two readings being documented. The SD of the PWVao was checked to inform the investigator about the quality of the measurement. When the SD for PWVao was  $\ge 0$  and  $\le 1.0 \text{ m} \text{ s}^{-1}$ , the measurement was regarded to be of good quality. However, measurement was rejected and repeated when SD PWVao was  $\geq 1.0 \text{ m s}^{-1}$ .

Each measurement was performed in accordance with the protocols of the Arteriograph device (Tensiomed).<sup>32</sup>

The PWVao and both aortic and brachial AIX were measured using the Arteriogaph with the formulas<sup>32</sup>:

PWVao (m/s) = Jug-Sy (m)/(RT/2 (s)

AIx (%) = (P2 - P1)/PP) × 100

#### Statistical analysis

Continuous variables were assessed for normality and homogenous variance at baseline using Shapiro–Wilk and Levene's test, respectively. Student's independent ttest or a Mann–Whitney U test was used to assess the difference between groups for all normally and nonnormally distributed baseline outcomes, respectively. Descriptive statistics were represented as the mean  $\pm$  SD.

To evaluate the interaction between treatment groups and time on parameters measured, mixed model repeated measures analysis of variance (ANOVA) was performed on continuous variables that met assumptions of normality, homogenous variance and sphericity (when sphericity was violated one of the epsilon correction factors (Greenhouse-Geisser) was consulted. Continuous variables that showed statistically significant interactions between groups at different time points were further analysed by performing a follow-up test, which, in this case, comprise a multiple independent t test with Bonferroni adjustment to avoid a type 1 error.

To evaluate interaction between treatment groups and time on parameters that did not meet assumptions of mixed model repeated measures ANOVA at all time points, a Mann–Whitney U test was conducted.

For continuous variable that were normally distributed with a homogeneous variance at either baseline, or at weeks 4 or 8, an independent t test was conducted to evaluate the interaction between groups and time.

Data were analysed using SPSS, version 22 (IBM Corp.). p < 0.05 was considered statistically significant. As this RCT is a pilot study, no sample size estimation



was conducted; however, the outcomes of this study will be of use to researchers who wish to carry out post-hoc sample size estimations.

### RESULTS

Ninety-one participants were screened for eligibility and 55 males were assigned to the intervention (Figure 1). The compliance rate was 90% in the vitamin D group and 87% in the placebo group. No adverse events of supplementation were reported.

Mean ± SD age was  $35.9 \pm 11.8$  years in the vitamin D group and  $33.1 \pm 12.2$  years in the placebo group. Participant characteristics at baseline in the different intervention groups are presented in Table 1. No significant differences at baseline were observed in the variables measured between groups, except for the vitamin D group having a slightly higher mean ± SD plasma glucose  $5.23 \pm 1.45$  vs.  $4.75 \pm 0.82 \pm \text{mmol L}^{-1}$  (p = 0.025) compared to the placebo group. At baseline, 22.2 % (n = 12), 35.2 % (n = 19) and 64.8% (n = 35) of participants had plasma 25(OH)D concentrations <25, <30 and <50 nmol L<sup>-1</sup>, respectively, independent of treatment group.

Based upon reported dietary consumption from the completed 3-day food diary at weeks 0 and 8 (n = 42), no significant difference was observed between the intervention and placebo group in mean daily dietary intake of energy, carbohydrate, protein, fats and vitamin D. Baseline dietary intake is presented in Table 1.

Daily intake of  $125 \,\mu\text{g}$  of vitamin D<sub>3</sub> within the vitamin D group, improved plasma 25(OH)D concentrations significantly, from a baseline mean  $\pm$  SD concentration of  $38.5 \pm 16.0$  to  $62.5 \pm 19.5$  nmol L<sup>-1</sup> (p < 0.001) at 4 weeks and  $72.5 \pm 16.8$  nmol L<sup>-1</sup> (p < 0.001) at 8 weeks (Figure 2). Participants in the vitamin D<sub>3</sub> group, 45.8% (11/24) reached a plasma 25(OH)D concentration >75 nmol L<sup>-1</sup> after 8 weeks of supplementation.

The key finding of the RCT was that Vitamin  $D_3$  supplementation led to a decrease in mean ± SD brachial pulse pressure from baseline to 8 weeksof  $-2.9 \pm 3.4$  mmHg, (p = 0.027) in the vitamin D group compared to the same period in the placebo group. The intervention had no effect on the remaining parameters (Table 2).

### DISCUSSION

This pilot RCT, investigated the effect of daily dietary oral supplementation with  $125 \,\mu g$  of vitamin D<sub>3</sub> for 8 weeks in overweight and obese adult males on a comprehensive array of cardiometabolic risk markers, including endothelial function, arterial stiffness, oxidative stress and insulin resistance. Vitamin D<sub>3</sub> supplementation significantly increased plasma levels of 25(OH)D after 8 weeks but did not significantly improve the cardiometabolic markers evaluated between intervention groups. Nevertheless, favourable effects were found in brachial PP because vitamin D<sub>3</sub> supplementation led to a decrease in mean  $\pm$  SD brachial PP from baseline to 8

TABLE 1 Baseline characteristics of the study population in the vitamin  $D_3$  and placebo group.

Parameters	Vitamin D <sub>3</sub>	Placebo	p
Plasma 25(OH)D (nmol $L^{-1}$ )	38.5±16	44.0 ± 19.5	0.544
Plasma PTH (pmol L <sup>-1</sup> )	$4.3 \pm 3.5$	$4.2 \pm 2.8$	0.917
Haemodynamic measures			
SBP (mmHg)	$128.7 \pm 11.1$	$131.2 \pm 12.8$	0.730
DBP (mmHg)	$77.0\pm9.7$	$78.0 \pm 12.9$	0.797
PWV (m $s^{-1}$ )	$6.5 \pm 1.1$	$6.5 \pm 1.1$	0.802
PP (mmHg)	$53.6\pm9.2$	$53.8\pm9.2$	0.846
MAP (mmHg)	95.1 ± 9.1	$95.9 \pm 12.0$	0.796
AIx (brachial) (%)	$-48.6 \pm 25.9$	$-51.5 \pm 22.2$	0.953
AIxao (aortic) (%)	$12.6 \pm 13.4$	$12.7\pm13.6$	0.940
SBPao (mmHg)	$118.5 \pm 12.9$	$119.5\pm16.9$	0.873
PPao (mmHg)	$41.6\pm8.8$	$41.3\pm8.7$	0.927
HR (bpm)	$62.3 \pm 12.3$	$60.9\pm10.8$	0.635
RT (m s <sup>-1</sup> )	$153.3 \pm 24.4$	157.6 ± 24.9	0.443
Cardiometabolic markers			
Plasma soluble E-selectin (ng ml <sup>-1</sup> )	57.9 ± 31.1	57.5 ± 18.9	0.312
Plasma hs-CRP $(mg L^{-1})$	$2.9 \pm 1.9$	$2.8 \pm 2.1$	0.480
Plasma 8-isoprostane (pg ml <sup>-1</sup> )	$11.2 \pm 8.7$	$8.9 \pm 5.7$	0.449
Plasma renin (pg ml <sup>-1</sup> )	$639.8\pm294$	$695.1\pm410.7$	0.716
Plasma angiotensin II (pg ml <sup>-1</sup> )	32.3 ± 9.6	31.8 ± 9.8	0.810
Plasma insulin (pmol L <sup>-1</sup> )	$46.5\pm27.7$	$42.1\pm37.0$	0.160
HOMA-IR	$1.6 \pm 1.3$	$1.4 \pm 1.6$	0.068
Plasma glucose (mmol L <sup>-1</sup> )	$5.2 \pm 1.5$	$4.8 \pm 0.8$	0.025
Blood lipids			
Plasma TC (mmol L <sup>-1</sup> )	$6.5 \pm 1.8$	$6.4 \pm 1.6$	0.758
Plasma TAG (mmol L <sup>-1</sup> )	$1.7 \pm 0.4$	$1.7\pm0.3$	0.665
Non-HDL-C (mmol $L^{-1}$ )	$6.3 \pm 1.8$	$6.2 \pm 2.2$	0.893
Plasma HDL-C (mmol $L^{-1}$ )	$0.6 \pm 0.1$	$0.7 \pm 0.2$	0.814
LDL-C (mmol $L^{-1}$ )	$5.2 \pm 1.5$	$5.0 \pm 1.6$	0.719
Anthropometry/dietary intake			
Age (years)	$35.9 \pm 11.8$	$33.1 \pm 12.2$	0.248
Body weight (kg)	$92.4 \pm 10.3$	90.4 ± 19.3	0.378

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0.071

0.085

0.194

0.110

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 $247.8 \pm 85.1$ 

 $3.1 \pm 3.1$ 

Placebo

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Body mass index (kg m<sup>-2</sup>)  $29.9 \pm 3.3$  $28.4 \pm 2.6$ Waist circumference (cm)  $93.5 \pm 22$  $91.3 \pm 8.0$ Energy (kcal day<sup>-1</sup>)  $1853.9 \pm 500.8$  $2141.7 \pm 663.8$ Energy (MJ dav<sup>-1</sup>)  $7.5 \pm 2.2$  $8.8 \pm 2.9$ Fat  $(g day^{-1})$ 68.4 ±14.2 82.0± 27.4 Protein (g day<sup>-1</sup>)  $83.9 \pm 24.5$  $106.9 \pm 56.9$ 

Vitamin D<sub>3</sub>

Values are presented as the mean  $\pm$  SD.

Carbohydrate (g  $day^{-1}$ )

Vitamin D (g day<sup>-1</sup>)

\**p* < 0.05

TABLE 1

Parameters

Abbreviations: 25(OH)D, 25 hydroxyvitamin D; AIx, aortic augmentation index; AIxao, brachial augmentation index; DBP, diastolic blood pressure; HDL-C, high density lipoprotein cholesterol; HOMA-IR, homeostasis model assessment of insulin resistance; HR, heart rate; hs- CRP, high sensitivity C-reactive protein; LDL-C, low density lipoprotein cholesterol; MAP, mean arterial pressure; non-HDL-C, non- high density lipoprotein cholesterol; PP, brachial pulse pressure; PPao, central aortic pulse pressure; PTH, parathyroid hormone, PWV, pulse wave velocity; RT, return time; SBP, systolic blood pressure; SBPao, central systolic blood pressure; sE-selectin, soluble E-selectin and TC, total cholesterol; TAG, triacylglycerol.

 $219.4 \pm 67.5$ 

 $1.6 \pm 1.2$ 

weeks of  $-2.9 \pm 3.4$  mmHg (p = 0.027) in the vitamin D group compared to the same period in the placebo group.

Although a previous systematic review and meta-analysis of nine RCTs reported significant improvement in arterial stiffness following supplementation in vitamin D deficient adults,<sup>33</sup> the findings of the present study are consistent with results from other studies that reported no significant effect of supplemental vitamin D on cardiometabolic markers.<sup>34,35</sup> A narrative review evaluating the effectiveness of vitamin D supplementation in 45 RCTs of various patient populations reported that no RCTs were effective in reducing stiffness in large arteries, or improving atherosclerotic and endothelial function markers with or without vitamin D deficiency.<sup>33</sup> Additionally, a RCT in 35 healthy participants with 25(OH) D concentrations below 75 nmol L<sup>-1</sup> found that 12 weeks of administration of 50 µg of vitamin D did not alter lipid profile, fasting plasma, insulin and hs-CRP concentrations.<sup>35</sup>

Even though plasma 25(OH)D concentration significantly improved in the vitamin  $D_3$  group in the present study, the majority of participants were unable to attain the 75 nmol L<sup>-1</sup> threshold. This could be attributed to adipose sequestration in the overweight/obese participants, as reports in humans demonstrate that approximately 17% of vitamin D given orally is stored in adipose tissue.<sup>36</sup> Furthermore, those with darker skin may have to supplement with higher doses to achieve optimal levels of plasma 25(OH)D than used in the present study.<sup>37</sup> Another possible reason for inability of some participants in the vitamin D<sub>3</sub> group to reach plasma 25(OH)D concentrations above 75 nmol L<sup>-1</sup> may be the decreased expression of 25-hydroxylase CYP2J



**FIGURE 2** Plasma 25(OH)D concentrations at each timepoint during the 8-week intervention in the vitamin D and placebo groups. Values are presented as the mean  $\pm$  SD indicated as vertical error bars. Asterisks above error bars denote a statistically significant within-group difference in plasma 25(OH)D concentration at that time point compared to baseline (week 0), analysed using the Mann–Whitney U test (p < 0.001).

and 1- $\alpha$  hydroxylase CYP27B1 in adiposity.<sup>38</sup> Additionally, it could also be ascribed to circulating vitamin D binding protein (VDBP) because VDBP has a greater binding affinity for 25(OH)D compared to 1,25(OH)<sub>2</sub>D<sup>39,40</sup> and levels of VDBP are reported to be reduced in acute inflammation, suggesting that, in obesity, which is characterised by chronic low-grade inflammation, circulating VDBP levels may be reduced.<sup>41,42</sup> Furthermore, VDR genotype polymorphisms particularly the VDR *ff* genotype, has been described to exhibit a low response to vitamin D intake and is also associated with adiposity.<sup>43-45</sup> Consequently, VDR genotype polymorphism in adiposity could be an additional explanation for the reduced individual response to a high dose of vitamin D<sub>3</sub> in the present study.

The impact of VDR genotype polymorphism that has been revealed to influence individual response to vitamin D intake in obese individuals was not evaluated in present study.<sup>41</sup> Assessing individual VDR genotype polymorphism in people with varying adiposity, particularly in the overweight and obese could be vital to understanding variability in individual response to oral intake of vitamin D.<sup>43</sup> However, few RCTs in overweight and obese participants have investigated the impact of VDR genotype polymorphisms on plasma concentrations of 25(OH)D.

The absence of a beneficial impact of high dose vitamin  $D_3$  supplementation on cardiometabolic risk markers in this study could be attributed to a number of factors. First of all, a higher dose and extended duration of supplementation with vitamin  $D_3$  may perhaps be needed, particularly in overweight/obese participants, because plasma 25(OH)D concentrations > 75 nmol L<sup>-1</sup> are needed for optimum extra-skeletal health.<sup>11</sup>

In the present study, enrolment of healthy participants with no known pathology at baseline may be a likely reason for the lack of changes observed in SBP, DBP and MAP compared to an 8-week Iranian study in hypertensive and vitamin D deficient outpatients.<sup>46</sup> The study revealed significant reductions in mean  $\pm$  SD SBP (-6.4  $\pm$  5.3 vs. 0.9  $\pm$  3.7 mmHg, p < 0.001), DBP (-2.4  $\pm$  3.7 vs. 1.0  $\pm$  2.7 mmHg, p = 0.003) and MAP (-3.7  $\pm$  3.6 vs. 0.9  $\pm$  2.5 mmHg, p < 0.001) in the vitamin D compared to placebo group, following an 8-week intake of 1250 µg vitamin D<sub>3</sub>.<sup>44</sup> The study found no significant impact of vitamin D<sub>3</sub> supplementation on pulse pressure.<sup>46</sup> In the absence of changes in blood pressure measurements, the change in brachial PP in the present study may be less impactful because brachial PP reflects changes in peripheral arteries and not in large conduit arteries, and is less effective than SBP or DBP in the predictive value of CVD risk.<sup>47</sup>

Additionally, using non-diabetic participants at baseline could be another potential reason for the absence of significant changes in insulin resistance and plasma levels of insulin and glucose. It is likely that supplementation with vitamin D<sub>3</sub> could be favourable in insulin resistant people, as significant reductions and improvement were observed in fasting insulin and insulin resistance respectively, following 6 months intake of 100 µg of vitamin D<sub>3</sub> in insulin resistant South Asian women who were vitamin D deficient (25(OH) D < 50 nmol L<sup>-1</sup>).<sup>48</sup> This RCT found a decrease in insulin resistance at a serum 25(OH)D concentration of 80–119 nmol L<sup>-1</sup>, showing a dose response relationship between vitamin D concentrations and insulin resistance.<sup>48</sup>

Most of the participants in the present study possibly have less established anatomical changes in their arterial tree because they were physically active and below the age of 50 years. Cardiometabolic risk increases with age, and only few participants above 50 years were recruited; thus, the ability to determine significant differences in this age group was limited. It is possible that vitamin D has differential effects dependent on specific cardiometabolic outcomes.<sup>49</sup>

Finally, it should be noted that the present study was a pilot intervention and, as such, there is a possibility that it TABLE 2 Effect of 8 weeks vitamin D<sub>3</sub> supplementation on cardiometabolic disease risk markers.

	Vitamin D <sub>3</sub> (n	= 24)		Placebo $(n = 24)$	4)		
Parameters	Baseline	Week 4	Week 8	Baseline	Week 4	Week 8	р
Plasma 25(OH)D (nmol L <sup>-1</sup> )	$38.5 \pm 16.0$	$62.5 \pm 19.5$	$72.5 \pm 15.8$	$44.0\pm19.5$	$39.0 \pm 17.5$	38.8± 18.0	< 0.001***
Plasma PTH (pmol L <sup>-1</sup> )	$4.3\pm3.5$	$4.5\pm3.5$	$3.7 \pm 3.0$	$4.2 \pm 2.8$	$4.4\pm2.8$	$4.9 \pm 3.1$	0.112
Haemodynamic measures							
SBP (mmHg)	$128.7\pm11.1$	$126.7\pm11.9$	$127.8 \pm 11.0$	$131.2\pm12.8$	$134.1\pm12.9$	$135.5\pm13.0$	0.099
DBP (mmHg)	$77.0\pm9.7$	$76.0 \pm 8.8$	$77.0\pm9.0$	$78.0 \pm 12.9$	$79.3 \pm 13.0$	$80.1 \pm 13.4$	0.522
PWV (m $s^{-1}$ )	$6.5\pm1.1$	$6.4 \pm 1.0$	$6.4\pm0.8$	$6.5 \pm 1.1$	$6.3\pm0.9$	$6.3\pm0.9$	0.423
PP (mmHg)	$53.6\pm9.2$	$49.4\pm3.9$	$50.7\pm5.8$	$53.8\pm9.2$	$53.5\pm6.4$	$55.4\pm9.7$	0.027*
MAP (mmHg)	$95.1\pm9.1$	$93.4\pm8.2$	$94.2\pm8.2$	$95.9 \pm 12.0$	$96.0 \pm 12.4$	$97.2 \pm 12.7$	0.413
AIx (brachial) (%)	$-48.6\pm25.9$	$-42.8 \pm 24.8$	$-33.2\pm12.6$	$-51.5 \pm 22.2$	$-45.5 \pm 13.1$	$-45.4 \pm 13.3$	0.940
AIxao (aortic) (%)	$12.6\pm13.4$	$16.1 \pm 13.9$	$15.7 \pm 14.1$	$12.7 \pm 13.6$	$11.5 \pm 9.6$	$12.5\pm16.8$	0.705
SBPao (mmHg)	$118.5\pm12.9$	$116.9 \pm 12.6$	$117.9 \pm 12.7$	$119.5\pm16.9$	$119.4 \pm 14.8$	$121.4\pm18.7$	0.347
PPao (mmHg)	$41.6\pm8.8$	$40.5\pm7.5$	$40.9\pm7.3$	$41.3\pm8.7$	$41.4 \pm 10.8$	$43.1\pm10.5$	0.280
HR (bpm)	$62.3 \pm 12.3$	$61.2\pm11.7$	$61.7 \pm 11.7$	$60.9 \pm 10.8$	$62.0 \pm 11.6$	$60.9 \pm 11.0$	0.904
$RT (m s^{-1})$	$153.3 \pm 24.4$	$153.9\pm26.4$	$154.4\pm28.1$	$157.6\pm24.9$	$162.9\pm27.6$	$159.5\pm27.3$	0.715
Cardiometabolic markers							
Plasma soluble E-selectin (ng ml <sup>-1</sup> )	$57.9\pm31.1$	$44.2\pm29.4$	$47.1\pm29.7$	$57.5 \pm 18.9$	39.2 ± 17.6	$40.4 \pm 16.0$	0.733
Plasma hs-CRP (mg L <sup>-1</sup> )	$2.9\pm1.9$	$2.4 \pm 1.7$	$2.7 \pm 1.4$	$2.8 \pm 2.1$	$3.1 \pm 2.1$	$2.6 \pm 2.1$	0.264
Plasma 8-isoprostanes (pg ml <sup>-1</sup> )	$11.2 \pm 8.7$	$16.5 \pm 11.1$	$14.6 \pm 11.5$	$8.9 \pm 5.7$	$15.8\pm12.5$	$16.4 \pm 13.2$	0.222
Plasma renin (pg ml <sup>-1</sup> )	$639.8\pm294$	$559.9 \pm 253.8$	$463.6\pm244.5$	$695.1\pm410.7$	$542.2\pm243.3$	$471.6\pm186.5$	0.610
Plasma angiotensin II (pg ml <sup>-1</sup> )	$32.3\pm9.6$	$31.0\pm6.7$	$29.5\pm4.6$	$31.8 \pm 9.8$	$32.7 \pm 12.5$	$27.9\pm7.3$	0.390
Plasma insulin (pmol L <sup>-1</sup> )	$46.5\pm27.7$	$43.6\pm26.9$	$46.0 \pm 17.3$	$42.1\pm37.0$	$48.3 \pm 42.4$	46.6 ± 39.9	0.897
HOMA-IR	$1.6 \pm 1.3$	$1.6 \pm 1.3$	$1.7 \pm 2.1$	$1.4 \pm 1.6$	$1.4 \pm 2.1$	$1.4 \pm 1.9$	0.680
Plasma glucose (mmol L <sup>-1</sup> )	$5.2 \pm 1.5$	$5.0 \pm 1.4$	$5.3 \pm 2.1$	$4.8 \pm 0.8$	$4.5\pm0.7$	$4.8\pm0.5$	0.209
Blood lipids							
Plasma TC (mmol L <sup>-1</sup> )	$6.2 \pm 1.3$	$6.8 \pm 1.6$	$7.5 \pm 1.5$	$6.4 \pm 1.6$	$6.8 \pm 2.0$	$7.3 \pm 1.7$	0.216
Plasma TAG (mmol L <sup>-1</sup> )	$1.7\pm0.4$	$1.6 \pm 0.4$	$1.7 \pm 0.5$	$1.7 \pm 0.3$	$1.6 \pm 0.3$	$1.6 \pm 0.2$	0.445
Non- HDL-C (mmol L <sup>-1</sup> )	$6.3\pm1.8$	$5.6 \pm 1.1$	$6.4 \pm 2.7$	$6.2 \pm 2.2$	$5.6 \pm 1.8$	$6.2\pm1.5$	0.740
Plasma HDL-C (mmol L <sup>-1</sup> )	$0.6 \pm 0.1$	$0.6 \pm 0.1$	$0.7 \pm 0.1$	$0.7\pm0.2$	$0.6 \pm 0.1$	$0.6 \pm 0.1$	0.250
$LDL -C \pmod{L^{-1}}$	$5.2 \pm 1.5$	$5.6 \pm 1.5$	$5.4 \pm 2.4$	$5.0 \pm 1.6$	$5.5 \pm 1.6$	$5.5 \pm 1.0$	0.416

Values are presented as the mean  $\pm$  SD. The *p* value represents the significance level for the change in parameters from baseline to week 8 in the vitamin D group compared to the change in the same parameter in the placebo group. Mixed model repeated measures analysis of variance was performed to determine the effect of the intervention.

was underpowered, and due to the large number of outcome variables there is a risk of type 1 error. Because there was no change in the primary outcome measure of PWV, the resulting effect size is low (0.12). Therefore, a post-hoc power calculation (two tailed) with 80% power and 0.5% significance level estimates a required sample size of 1140 participants per group (G\*Power, version 3.1.9.7; http:// www.gpower.hhu.de).

The present study has a number of strengths, such as the randomised double-blind, placebo-controlled design, as well

as a strong and reliable evidence of a treatment effectiveness that permits causal inferences to be drawn.<sup>50</sup> The present study also evaluated a number of cardiometabolic markers at various time points, which, over time, are capable of tracking an effect, and the study also controls for influences that induce variations between subjects.<sup>51</sup>

In summary, supplementation with an 8-week daily dose of  $125 \,\mu g$  of vitamin D<sub>3</sub> in overweight and obese adult males did not lead to a significant improvement in the cardiometabolic markers measured. However, in the vitamin D group,

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PP significantly decreased from baseline to 8 weeks compared to the change in the placebo group. Overall, the findings of this pilot RCT did not demonstrate the efficacy of vitamin D supplementation in improving cardiometabolic risk biomarkers in the cohort of overweight/obese adults over the 8-week duration. Further large-scale clinical trials over longer durations may offer additional insights.

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#### AUTHOR CONTRIBUTIONS

IHND

Tarimoboere Agbalalah drafted the study and manuscript under the supervision of Sohail Mushtaq. All authors 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.

#### CLINICAL TRIAL REGISTRATION

http://www.clinicaltrials.gov NCT02359214.

#### 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<sup>25</sup> guidelines. The lead author affirms no important aspect of the study was omitted and that any discrepancies from the study as planned have been explained.

### ETHICS STATEMENT

The author affirms that all participants provided written informed consent and trial was performed in accordance with the Helsinki Declaration. Author affirms ethical approval was obtained for all participants and trial was registered at clinicaltrials.gov (NCT02359214).

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#### PRINCIPLES OF NUTRITION AND DIETETICS

# Facilitators and barriers to providing culinary nutrition, culinary medicine and behaviour change support: An online cross-sectional survey of Australian health and education professionals

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#### Abstract

Background: An Australia wide cross-sectional online survey examined facilitators and barriers of health and education professionals to providing culinary nutrition (CN) and culinary medicine (CM) education and behaviour change support in usual practice, in addition to identifying continuing professional development (CPD) needs in this domain.

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Methods: Survey items included socio-demographic characteristics, cooking and food skills confidence, nutrition knowledge (PKB-7), fruit and vegetable intake (FAVVA) and CPD needs. Data were summarised descriptively.

**Results:** Of 277 participants, 65% were likely/somewhat likely to participate in CN CPD. Mean (SD) cooking and food skill confidence scores were 73 (17.5) and 107.2 (24), out of 98 and 147, respectively. Mean PKB-7 score was 3.7 (1.4), out of 7. Mean FAVVA score was 98 (29), out of 190.

Conclusions: Gaps in knowledge and limited time were the greatest modifiable barriers to providing CM/CN education and behaviour change support in practice. Health and education professionals are interested in CPD conducted by dietitians and culinary professionals to enhance their knowledge of CM/CN and behaviour change support.

#### **KEYWORDS**

continuing professional development, culinary medicine, culinary nutrition, intervention

#### Key points

- Poor knowledge is a barrier to providing education about nutrition, cooking and food skills and to providing support to others to improve food behaviour.
- Participants want to understand differences between special diets and 'fad' diets.
- Health and education professionals are interested in continuing professional development to enhance their knowledge of culinary nutrition education and behaviour change support.

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# INTRODUCTION

Diet plays an important role in prevention and treatment of non-communicable diseases.<sup>1</sup> However, fewer than 10% of Australian adults consume the daily recommended serves of vegetables and 35% of total daily energy intakes are derived from energy-dense, nutrientpoor foods.<sup>2</sup> The World Cancer Research Fund International's NOURISHING framework guides policy action for promotion of healthy eating to reduce the non-communicable disease burden. The framework identifies nutrition, food preparation and cooking skill programs as an area for action, with a focus on behaviour change communication, including providing opportunistic nutrition advice and counselling in health care settings and providing nutrition education and developing food skills.<sup>3</sup>

Dietitians provide personalised nutrition advice, often for complex medical conditions.<sup>4</sup> However, other health professionals could support patient's food-related behaviour change within their usual scope of practice through provision of general evidence-based nutrition information and behaviour change support.<sup>5,6</sup> Providing opportunistic patient support has been targeted in smoking cessation, alcohol reduction and increasing physical activity.<sup>7</sup> Health professionals could support nutrition education to patients, including pregnant women,<sup>8,9</sup> and in chronic conditions such as weight management,<sup>10,11</sup> type 2 diabetes and cardiovascular disease.<sup>11,12</sup> However, these opportunities are often missed.<sup>5</sup> Barriers and enablers to providing opportunistic health behaviour change support align into four themes: (1) perception of health professionals' knowledge and skills; (2) perceptions about their role; (3) resources and support needs; and (4) health professional's practice.<sup>7</sup> Time and a practitioners perception of scope of practice are both barriers to providing opportunistic health behaviour change support.<sup>7,10</sup> Insufficient nutrition training of medical and other health professionals is a barrier, with the current level being insufficient to assist them in helping their patients make healthier food choices.<sup>13–15</sup> More comprehensive nutrition training for healthcare providers could address this issue.<sup>13,15,16</sup> Culinary interventions, including nutrition, cooking and food skill education, could be used to target dietrelated risk behaviours.<sup>17</sup> Some positive effects have been shown for fruit and vegetable intakes, knowledge, skills and cooking confidence.<sup>17,18</sup>

Culinary medicine (CM) and culinary nutrition (CN) programs combine health and nutrition education with culinary arts, including food preparation and cooking, and utilise the relationship between nutrition-related health and culinary practices.<sup>19,20</sup> CM considers social and cultural elements of food and eating, and the role of food in prevention and treatment of disease.<sup>20</sup> CM programs for health and medical practitioners teach nutrition by developing skills needed for both their own

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healthy dietary behaviours and their patients and clients, including meal planning, food preparation and cooking skills.<sup>20,21</sup> CN combines food science and nutrition with culinary arts to promote sustainable eating patterns to support health.<sup>19</sup> CN programs can be delivered by community health workers, educators, dietitians, nutritionists, students of health disciplines or peer leaders and may include chefs.<sup>17,18</sup>

Preliminary CM and CN program evaluations suggest that they are feasible, acceptable and may be effective in supporting nutrition and cooking education among trainee medical,<sup>22–25</sup> nutrition and dietetic undergraduates,<sup>26,27</sup> and health professionals.<sup>28</sup> CM education delivered to trainee health professionals within a teaching kitchen may be associated with better outcomes compared to traditional classroom-based learning, including improved dietary intakes for medical students and patient nutrition counselling competence.<sup>29,30</sup> Education professionals who teach culinary arts and/or nutrition in adult and community settings are also well placed to provide CN related behaviour change support to their learners and students. We found no studies of facilitators and barriers to education professionals that provide this CN related behaviour change support. CM programs to date have rarely been conducted in Australia, none have been rigorously evaluated and few CM programs provide an adequate description of factors informing their development.<sup>31</sup>

Therefore, the present study surveyed health professionals and education professionals who work with patients or clients or teach adult cooking and/or nutrition in community settings, aiming to inform the development of a CM/CN continuing professional development (CPD) program. Specific aims, with respect to health and education professionals, were to assess: (1) cooking, food preparation and meal planning confidence, nutrition knowledge and dietary intake; (2) barriers and facilitators to provision of CM/CN education and behaviour change support in usual practice; and (3) personal preferences for CPD in this area.

### METHODS

This cross-sectional online survey of Australian health and education professionals with the ability to potentially provide CM/CN education and behaviour change support to their patients, clients, adult learners or students, to improve dietary patterns, was undertaken in September 2019. The study reporting aligned with the STROBE checklist for cross-sectional studies.<sup>32</sup>

#### **Participants**

Eligibility included living in Australia, aged  $\geq$  18 years, currently working in a health-related role (e.g., medical

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physician, nurse, allied health) that included face-toface contact either individually or with groups of patients or clients. Education professionals were eligible if they taught cooking and/or nutrition in either community education or adult education settings. There was no restriction regarding whom those programs targeted or the setting (e.g., out of school hours or vacation care, workplace). Exclusion criteria were education professionals teaching in early childhood education, or primary or secondary schools, exclusively. The sample size was selected to obtain meaningful representation of health professionals consistent with Australian workforce representation.<sup>33</sup> This is characterised by the highest number of health staff being from the professions of nursing, followed by allied health, medical and then dental health professions.

#### Survey

The online survey participants were recruited using Qualtrics Research Services (Qualtrics LLC). The service was responsible for the recruitment of all participants, distribution of surveys and data collection.<sup>34</sup> There were no differences in how health and education professionals were recruited. Survey commencement was taken as consent and all results were anonymous. The survey consisted of both closed quantitative data questions (n = 150) and one openended question. Completion time was approximately 20 min. The questionnaire was pre-tested with five practising health and education professionals for content validity and usability (i.e., readability, clarity, relevance and survey length) and revisions were made to wording in response to feedback provided. The University of Newcastle Human Research Ethics Committee approved the project (Approval number H-2019-0166).

Survey domains included cooking and food skills confidence<sup>35</sup>; diet quality<sup>36</sup>; nutrition knowledge<sup>37</sup>; usual practice regarding provision of cooking, meal planning, nutrition and health behaviour change advice in the context of health or education practice, and barriers and facilitators to doing this<sup>10,15,38</sup>; CPD activity preferences<sup>10,15,38</sup>; and preferred delivery mode, format and content in regard to a CM/CN CPD course. Validated instruments were used to measure cooking and food skills confidence, diet quality, and nutrition knowledge.<sup>35–37</sup> Questions to measure barriers and facilitators to provision of nutrition, cooking, meal planning and/or health behaviour change, as well as CPD preferences, were modified from existing surveys.<sup>10,15,38,39</sup> Questions to measure preferred delivery mode, format and content for a CM/CN CPD course were developed specifically for the survey.

#### Cooking and food skills confidence

The health and education professionals' own food preparation and cooking skills, and food skills confidence was assessed using a survey based on the validated cooking and food skill confidence questionnaire of Lavelle et al.<sup>35</sup> This survey consists of 33 questions with response captured on an eight-point Likert scale, ranging from 7 'never/rarely' (0) to 'very good' (7).<sup>7,35</sup> Two items ('prepare and cook raw meat/poultry' and 'prepare and cook raw fish') were omitted from the original cooking skills confidence measure of Lavelle et al.<sup>35</sup> and replaced with two vegetable specific cooking skill confidence items ('make a salad dressing' and 'make a salad from scratch'). Two items ('use vegetables as snacks' and 'have fresh vegetables available for salads or side dishes') were added to the food skill confidence measure. Overall cooking and food skills confidence scores were calculated for each of the three professional groups (health, adult education, community education professionals) based on questions on cooking and food skills developed by of Lavelle et al.<sup>35</sup> Food skills are reported with and without the additional items. The total score for the 14-item cooking confidence measure was 98, whereas the highest possible score for the original 19-item and modified 21-item meal planning and food skill confidence measure was 133 and 147, respectively.

#### Nutrition knowledge

Nutrition knowledge was assessed using the Practical Knowledge about Balanced meals (PKB-7), a seven-item tool used to assess understanding of what constitutes a balanced meal.<sup>37</sup> An incorrect response scored 0, and correct responses scored 1. The total PKB-7 score ranges from 0 (low knowledge) to 7 (high knowledge).

### **Diet quality**

Diet quality was assessed using the Fruit And Vegetable VAriety Index (FAVVA) 36 as a brief measure of frequency and variety related to vegetable and fruit intake. FAVVA consists of 35 questions with higher scores shown previously to be associated with higher plasma carotenoid concentrations, a biomarker of carotenoid rich vegetable and fruit intake.<sup>36</sup> The maximum possible score is 190 points, indicating a high frequency and variety of vegetables and fruit. A score of 0 indicates no intake of any vegetable and fruit items included in the measure. Points are awarded based on frequency of intake of specific vegetables and fruit, with 0 points awarded for a response 'never consumed', up to 5 points for a response of '5 or more times per week'.<sup>36</sup> A comprehensive list of vegetable and fruit items are included in the tool with additional points available for

frequently consumed vegetables (peas, carrots, broccoli) and fruit (apples, oranges, bananas). These higher scoring options were 'once per day' (6 points) and ' $\geq 2$  times per day' (7 points).

# Barriers and facilitators to provision of advice in practice

Barriers and facilitators to provision of nutrition advice in practice were derived from previous surveys.<sup>10,15,38</sup> These barriers and facilitators related to whether participants provided food preparation and cooking; food skills; and nutrition related health behaviour change advice to patients, clients, adult learners or students, and whether they perceived this to be within, or should be within their scope of practice. Because the barriers for health and education professional groups differ as a result of their context of work, the response options were presented slightly differently. Participants were able to select as many barriers as applied to their situations. Participants were asked to rate their knowledge and skills in providing education to their patients, clients and students about food preparation, cooking, food skills and meal planning, and nutrition-related health behaviour change. Two questions related to barriers and facilitators to their own healthy eating practices were also included, as modified from a survey by Ashton et al.<sup>39</sup>

#### CPD activities and course preferences

Questions examining CPD activities and sources were obtained from three previous surveys <sup>10,15,38</sup> and adapted for the aims and population of the present study. Participants were asked about their interest in and preferences regarding CM/CN CPD education course content, delivery mode, session length and duration.

#### Statistical analysis

Qualtrics data cleaning involved removing straightliners, speed completers and gibberish responses. Further data cleaning was conducted by the research team. This included removing responses where survey completion was less than half the median time because this was not considered sufficiently long to provide quality responses. To further ensure only quality responses were included in analysis a reverse coded 'attention check' question was included, and text responses were reviewed for inappropriate text.

STATA Statistical/Data Analysis 15.1 (StataCorp) was used to analyse data quantitatively.

Mean score (M) and standard deviations (SD) are reported for whole group and subgroup analysis performed An Nutrition and Dietetics

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on cooking and food skill confidence scores. Subgroup analysis for cooking and food skills confidence was performed on participants reporting they were likely or somewhat likely to participate in a CM/CN course even if it was not accredited CPD, as well as for participants who perceive that provision of food preparation and cooking is or should be within their scope of practice. Subgroup analysis based on profession was performed for overall cooking and food skill confidence scores, nutrition knowledge and diet quality scores. Participants were categorised as a health professional, community cooking and/or nutrition education professional (i.e., not in a school) and adult cooking and/or nutrition education professional (i.e., not school-aged). Community cooking and/or nutrition education and adult cooking and/or nutrition education professional groups were collapsed into one group and reported as education professionals because there were no significant difference between these groups. Further between group analysis were conducted using a t test and a non-parametric Wilcoxon rank sum test, where appropriate. Cronbach's alpha was used to test the internal consistency and reliability of the adapted cooking and food skill confidence questionnaire. p < 0.05 was considered statistically significant.

Frequency and corresponding percentages are reported for subgroup analysis performed on barriers and facilitators to provision of nutrition advice in practice, and CPD activities and preferences. For barriers and facilitators subgroup analysis was performed for health or education professional. For CPD activities and course preferences, subgroup analysis was performed on participants reporting that they were likely or somewhat likely to participate in the course even if it was not accredited CPD.

### RESULTS

In total, 375 participants completed the survey. Of the 98 removed, 12 occurred during the Qualtrics data cleaning process, five did not meet inclusion criteria, 42 failed the reverse coded 'attention check' question, 25 completed the survey in less than half the median time and 14 had inappropriate responses to text questions. The final sample of 277 participants eligible for inclusion in the analysis comprised 224 (81%) health professionals, 29 (10%) adult education professionals and 24 (9%) professionals from community education. The overall sample had a mean (SD) age of 33 (11.1) years, a mean (SD) body mass index of 25.5 (5.6) kg m<sup>-2</sup>, a predominance of females (n = 183, 66%), almost half had a bachelor's degree (n = 134; 48%) and the majority were in full time employment (n = 175; 63%). Most participants were the primary person in their household responsible for meal provision with 74% (n = 205) responding 'most of the time'. Thirty percent (n = 66) of health professionals had practised in their health discipline for less than 3 years

 TABLE 1
 Characteristics of participants of heath, adult and community education professionals

Characteristic $(n = 277)$	n	%	Mean	SD
Adult education	29	10	_	_
Community education	24	8.7	-	-
Health professional	224	81	_	_
Age	277	_	33.1	11.1
Body mass index	277	_	25.5	5.6
Female	183	66.1	_	-
<i>Meal provision</i> $(n = 277)$				
Most of the time	205	74	_	_
Sometimes	41	14.8	_	_
About half of the time	21	7.6	_	_
Rarely	8	2.9	_	_
Never	2	0.7	_	_
Highest education (health) (n	= 224)			
Postgraduate	63	28.1	_	-
Bachelor degree	111	49.6	_	-
Trade certificate/diploma	43	19.2	_	-
Year 12	5	2.2	_	_
Year 11	1	0.5	_	_
Year 10	1	0.5	_	_
Years practising (health) (n =	= 224)			
< 3 years	66	29.5	_	_
3-5 years	55	245.6	_	_
5-10 years	49	21.8	_	_
> 10 years	54	24.1	_	_
Health disciplines $(n = 224)$				
Nursing	83	37.1	_	-
Medical	16	7.6	_	-
Allied health assistants	26	11.6	_	-
Physiotherapy	14	6.2	_	-
Occupational therapy	9	4.0	_	-
Dietetics	3	1.3	_	_
Speech pathology	2	0.9	_	-
Podiatry	1	0.5	_	-
Psychology	9	4.0	_	-
Social work	12	5.4	_	-
Exercise physiology	3	1.3	-	-
Pharmacy	10	4.5	-	-
Medical imaging	8	3.6	-	-

TABLE 1 (Continued)

Characteristic $(n = 277)$	n	%	Mean	SD
Dentistry and oral health	15	6.7	-	_
Other	13	5.8	-	_
Years practising (education)	(n = 53)			
< 3 years	18	34	_	_
3-5 years	26	49.1	_	_
5-10 years	8	15.1	_	_
> 10 years	1	1.9	_	_
Highest education (adult educ	<i>ation)</i> (r	n = 29)		
Postgraduate	13	44.8	-	_
Bachelor degree	13	44.8	_	_
Trade certificate/diploma	3	10.3	-	_
Highest education community	educatio	<i>n</i> (n = 24)		
Postgraduate	4	16.7	_	_
Bachelor degree	10	41.67	_	_
Trade certificate/diploma	5	20.8	_	_
Year 12	3	12.5	_	_
Year 11	1	4.1	_	_
Year 10	1	4.1	-	_

and 22% (n = 49) had practised for 5–10 years with a mean (SD) time spent with patients/clients per session of 41 (34) min. This was in comparison to 49% (n = 26) of education professionals reporting 3–5 years practising and a mean (SD) time spent with students of 46 (43) min per session. Participant characteristics are summarised in Table 1.

Almost two-thirds of participants (n = 180; 65%) were likely or somewhat likely to participate in a CN CPD course and were prepared to even if it was not recognised as a CPD activity by their professional association (Table 2). An even greater number (n = 234; 84.5%) reported that, if the CPD course was recognised by their professional association, they were likely or somewhat likely to participate. When asked if health behaviour change counselling was within their scope of practice, over half of the participants (n = 161; 58.1%) reported that it was within their scope. Of the 116 participants who reported that it was not within their scope of practice, % (n = 71) also felt that it should not be within their scope of practice.

#### Cooking and food skills confidence

Food preparation and cooking skill confidence and meal planning and food skill confidence scores are

TABLE 2 Summary of perceived scope of practice

	Yes, within scope of	f practice	Not within scope of pr should be <sup>a</sup>	actice, but	Not within scope of pra not be <sup>a</sup>	ctice, and should
Scope of practice	Frequency (n)	Percent	Frequency (n)	Percent	Frequency (n)	Percent
Nutrition education	160	57.8	47	17	70	25.3
Food preparation and cooking skills education	122	44	59	21.3	96	34.7
Food skills and meal planning education	126	45.5	53	19.1	98	35.4
Health behaviour change counselling	161	58.1	45	16.2	71	25.6
Total ( <i>n</i> = 277)	-	-	-	_	-	-

<sup>a</sup>Participants indicating 'no, not within scope of practice' were asked if it should be.

summarised in Table 3. Highest reported cooking confidence scores for all participants were for chopping/mixing/stirring food (mean [SD] = 5.6 [1.6], range 0–7), peeling and chopping vegetables (mean [SD] = 5.5 [1.7], range 0–7), boiling/simmering food (mean [SD] = 5.5 [1.5], range 0–7) and making a salad from scratch (mean [SD] = 5.5 [1.7]). All groups reported low confidence scores for making sauces and gravy from scratch (mean [SD] = 4.7 [1.9]), baking cakes/bread/buns (mean [SD] = 4.8 [1.8], range 0–7) and stewing food (mean [SD] = 4.9 [2.0], range 0–7).

Highest reported food skill confidence scores by all participants were for reading the 'best before' date on food (mean [SD] = 5.6 [1.6]), shopping with specific meals in mind (mean [SD] = 5.7 [1.4]), keeping basic meal items in the cupboard (mean [SD] = 5.4 [1.6]) and reading storage and use-by information on packages (mean [SD] = 5.6 [1.6]). In all groups, the lowest confidence scores were reported for using vegetables as snacks (mean [SD] = 4.6 [1.9]), buying food in season (mean [SD] = 4.8 [1.8]) and buying cheaper cuts of meat to save money (mean [SD] = 4.8 [1.9]).

Total food and cooking skill confidence scores by professional group are presented in Table 4. There were non-statistically significant mean (SD) higher food preparation and cooking skill confidence scores 77.1 (15.9) and food skill confidence scores 101.6 (19.7) reported by community educators compared to other groups.

Cronbach's alpha indicated high internal consistency and reliability for the adapted scale. Cronbach's alpha for the adapted 14-item cooking skill confidence scale was 0.92, this compared to Cronbach's alpha ranging from 0.79 to 0.93 in reliability testing conducted in Lavelle et al.<sup>35</sup> Cronbach's alpha for the adapted 21-item and unaltered 19-item food skill confidence scale was 0.94 and 0.93, respectively, compared to Cronbach's alpha ranging from 0.89 to 0.94 reliability testing as conducted by Lavelle et al.<sup>35</sup>

#### Nutrition knowledge

The mean (SD) PKB-7 score across all groups was 3.7 (1.4) (range 0–7). Health professionals and community educators had the highest mean nutrition knowledge scores (mean [SD] = 3.8 [1.4], range 0–7) and (mean [SD] = 3.8 [1.3], range 0–7), respectively, whereas adult educators (mean [SD] = 3.0 [1.7], range 0–7) had the lowest. All groups had moderate levels of nutrition knowledge with no significant differences between health professionals and education professionals, nor community education versus adult education professionals.

### **Dietary quality**

The mean (SD) FAVVA score across all participants was 98 (29.1) (range 0–190). Mean (SD) FAVVA scores for participants in the 'likely/somewhat likely' to participate in the course even if not considered accredited CPD (mean [SD] = 99.6 [32.9], range 0–190) were significantly higher than those not likely to participate in the course (mean [SD] = 95.2 [20.9], range 0–190). When scores were assessed by profession, educators had a significantly higher mean score (mean [SD] = 112.9 [24.3], range 0–190) compared to health professionals (mean [SD] = 94.6 [29.3], range 0–190).

# Barriers and facilitators to provision of advice in practice

A majority of participants reported that they had received nutrition education (n = 191; 69%) and health behaviour change education (n = 148; 53%) as part of their entry level professional qualification. A majority of education professionals reported that they had received cooking/food preparation (n = 41; 77%) and meal planning/food skills education (n = 42; 79%) as part of their entry level professional qualification. A majority of

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TABLE 3	Summary of individual cooking and food skill confidence scores <sup>35</sup>	<sup>5</sup> for all participants and across subgroups <sup>a</sup>

Food preparation and cooking skill confidence	Total survey participants (	(n = 277)	Willing to particular accredited C	Willing to participate in non- accredited CPD course $(n = 180)$		Perceived to be within scope of practice $(n = 122)$	
(14 items)	Mean	SD	Mean	SD	Mean	SD	
Total score	73.0	17.5	73.0	17.1	74.9	16.8	
Peeling and chopping vegetables	5.5	1.7	5.4	1.7	5.6	1.5	
Chopping mixing and stirring food	5.6	1.6	5.5	1.8	5.7	1.5	
Make sauces and gravy from scratch <sup>b</sup>	4.7	1.9	4.8	1.8	5.0	1.7	
Use herbs and spices to flavour food	5.4	1.6	5.4	1.5	5.4	1.6	
Make a salad dressing	5.0	1.9	5.0	1.8	5.2	1.7	
Make a salad from scratch	5.5	1.7	5.5	1.6	5.6	1.7	
Roasting food	5.2	1.6	5.2	1.6	5.4	1.6	
Frying/stir frying food	5.4	1.7	5.3	1.7	5.5	1.5	
Microwaving food	5.2	2.1	5.1	2.1	5.2	2.0	
Baking cakes/bread/ buns <sup>b</sup>	4.8	1.8	4.9	1.8	5.0	1.8	
Blending food	5.2	1.8	5.2	1.7	5.3	1.7	
Steaming food	5.2	1.9	5.2	1.8	5.3	1.7	
Boiling or simmering food	5.5	1.5	5.5	1.6	5.6	1.5	
Stewing food <sup>b</sup>	4.9	2.0	5.0	1.8	5.1	1.7	
		Total survey	Willing	to participate in non-	Perceived to be	within scope of	

Meal planning and food skill confidence	Total surve respondents	(n = 277)	Willing to accredited	participate in non- CPD course ( <i>n</i> = 180)	Perceived to practice (n =	b be within scope of = 126)
(21 items)	M	SD	M	SD	M	SD
Total score	107.2	24.0	107.4	23.0	112.3*	24.1
Planning meals in advance	4.9	1.7	4.9	1.7	5.4	1.5
Preparing meals in advance	5.0	1.7	5.0	1.7	5.4	1.4
Using vegetables as snacks <sup>b</sup>	4.6	1.9	4.8	1.8	5.1	1.8
Following recipes when cooking	5.2	1.6	5.3	1.5	5.2	1.7
Shopping with a grocery list	5.3	1.7	5.2	1.7	5.4	1.7
Shopping with specific meals in mind	5.4	1.6	5.3	1.7	5.7	1.4
Planning how much food to buy	5.2	1.5	5.0	1.6	5.3	1.5
Comparing prices before you buy	5.1	1.8	5.0	1.8	5.2	1.8
Knowing what budget you have to spend on food	5.1	1.7	5.1	1.7	5.2	1.7
Buying food in season to save money <sup>b</sup>	4.8	1.9	4.9	1.8	5.1	1.8
Buying cheaper cuts of meat to save money <sup>b</sup>	4.8	2.0	4.8	1.9	5.1	1.8
Cooking more or double recipes which can be used for another meal	5.2	1.8	5.1	1.8	5.5	1.7
Preparing or cooking a healthy meal with only a few ingredients on hand	5.1	1.6	5.2	1.5	5.3	1.5

#### TABLE 3 (Continued)

Meal planning and food skill confidence	Total survey respondents (	(n = 277)	Willing to accredited	participate in non- CPD course ( <i>n</i> = 180)	Perceived to practice (n	to be within scope of = 126)
(21 items)	M	SD	M	SD	M	SD
Preparing or cooking a meal with limited time	5.1	1.7	5.2	1.6	5.3	1.7
Using leftovers to create another meal	5.0	1.8	5.1	1.7	5.3	1.7
Keeping basic items in your cupboard for putting meals together (e.g., herbs/spices)	5.4	1.7	5.4	1.6	5.6	1.7
Keeping fresh vegetables on hand to make salads and side dishes	5.0	1.7	5.0	1.7	5.4	1.6
Reading best before date on food	5.5	1.6	5.3	1.7	5.6	1.6
Reading the storage and use-by information on food packets	5.4	1.6	5.3	1.6	5.6	1.5
Reading the nutrition information on food labels	5.2	1.8	5.2	1.7	5.3	1.8
Balancing meals based on nutrition advice of what is healthy	5.0	1.7	5.1	1.5	5.2	1.6
	Range: min =	= 0, max = 7				

Abbreviation: CPD, continuing professional development.

<sup>a</sup>For all survey participants (column A), participants stating that they would participate in the course if it was not recognised as accredited professional development (column B), food preparation and cooking skills confidence scores if food preparation and cooking education is perceived to be within scope of practice (column C). <sup>b</sup>Three lowest reported confidence scored for food preparation and cooking skills. \*p < 0.05.

 TABLE 4
 Total cooking skill, food skill confidence scores,<sup>35</sup> nutrition knowledge and FAVVA intake by professional group

	Health professional $(n = 224)$		Education	professional (n = 53)	Total ( <i>n</i> = 277)	
	Mean	SD	Mean	SD	Mean	SD
Total cooking skill confidence score (14 items)	72.6	17.9	74.7	15.3	73.0	17.5
Total food skill confidence score (19 items)	97.1	22.1	99.4	20.2	97.6	21.7
Nutrition knowledge (PKB-7 score, 7 items)	3.8	1.4	3.4	1.5	3.7	1.4
FAVVA score (190 items)*	94.6	29.3	112.9	24.3	98.1	29.3

Note: A higher score indicates higher confidence across all cooking and food skill items.

p < 0.001 between health professional and education professionals.

Abbreviation: FAVVA, fruit and vegetable intake; PKB-7, Practical Knowledge about Balanced meals (a seven-item tool).

health professionals reported that they had not attended nutrition education (n = 124; 55%), cooking/food preparation (n = 150; 67%), meal planning/food skills (n = 153; 68%) or health behaviour change education (n = 124; 55%) CPD. A majority of education professionals reported that they had attended nutrition education (n = 44; 83%), cooking/food preparation (n = 40; 75%), meal planning/food skills (n = 37; 69%) and health behaviour change education (n = 39; 74%) CPD.

A 'lack of knowledge' was the most frequently reported barrier to health professionals providing nutrition education (n = 70; 31%) and health behaviour change counselling (n = 52; 23%) to others (Table 5). The most frequently reported barrier for health professionals was a 'lack of time' for food preparation and cooking (n = 64; 29%) and meal planning/food skills (n = 54; 24%).

Education professionals most frequently reported 'no barriers' to providing nutrition education (n = 21; 40%) (Table 6). A lack of 'knowledge in the area' was the most frequently reported barrier to providing nutrition education (n = 14; 26%). Similarly, when asked about barriers to food preparation and cooking education, education professionals most frequently reported 'no barriers' (n = 16; 30%). Of the barriers identified by education professionals 'characteristics of the student group' (n = 14; 26%), was the most frequently reported barrier to food preparation and cooking education, meal planning (n = 15, 28%), and health behaviour change counselling (n = 15; 28%). Other more frequently reported barriers included 'knowledge in the area' of meal planning (n = 14; 26%) and for health behaviour change education (n = 14; 26%).

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**TABLE 5** Barriers reported by health professionals (*n* = 224) to providing nutrition education, food preparation and cooking education; meal planning and food skills education; and behaviour change counselling

	Nutrition		Food preparation cooking	and	Meal planning ar	nd food skills	Health behaviou	r change
Barriers	Frequency (n)	Percent	Frequency (n)	Percent	Frequency (n)	Percent	Frequency (n)	Percent
No barriers	35	16	35	15	40	18	49	22
No evidence for effectiveness	18	8	16	7	13	6	11	5
Lack of skills	38	17	49	22	32	14	37	17
Lack of knowledge	70	31 <sup>a</sup>	49	22	49	22	52	23 <sup>a</sup>
Referrer related	52	23	33	15	30	13	34	15
Characteristics of client group	47	21	48	22	42	19	32	14
Management related	25	11	33	15	30	13	37	17
Lack of resources	41	18	56	25	50	22	44	20
Lack of time	61	27	64	29 <sup>a</sup>	54	24 <sup>a</sup>	48	21
Lack of staff	36	16	39	17	30	13	33	15
Other	9	9	12	5	13	6	8	4

Note: Respondents could select all that apply.

<sup>a</sup>Most frequently reported barriers.

**TABLE 6** Barriers reported by education professionals (n = 53) to providing nutrition education, food preparation and cooking education; meal planning and food skills education; and behaviour change counselling

	Nutrition		Food preparation	and cooking	Meal planning an	d food skills	Health behaviou	ir change
Barriers	Frequency (n)	Percent	Frequency (n)	Percent	Frequency (n)	Percent	Frequency (n)	Percent
No barriers	21	40 <sup>a</sup>	16	30 <sup>a</sup>	12	23	7	13
No evidence for effectiveness	5	9	7	13	4	8	5	9
Skills in the area	10	19	8	15	6	11	13	25
Knowledge in the area	14	26	12	23	14	26	14	26
Parent's expectations	8	15	7	13	12	23	7	13
Characteristics of student group	9	17	14	26	15	28 <sup>a</sup>	15	28 <sup>a</sup>
Management related	8	15	12	23	6	11	7	13
Lack of time	8	15	8	15	6	11	9	16
Staffing	2	4	3	6	4	8	6	11
Other	0	0	0	0	1	2	1	2

Note: Respondents could select all that apply.

<sup>a</sup>Most frequently reported barriers.

### CPD activities and course preferences

The most requested nutrition topics by participants likely or somewhat likely to participate in a CN CPD course were 'goal setting for healthy eating' (n = 93; 53%), 'behaviour change/health coaching for healthy eating' (n = 92; 51%) and 'understanding special

versus 'fad' diets' (n = 90; 51%) (Table 7). The most requested content by these participants was 'simple vegetable recipes for meals, sides, snacks' (n = 93; 52%), 'cooking for different cultural groups' (n = 87; 49%) and 'using limited ingredients or utilising leftovers' (n = 74; 41%) (Table 7). Lastly, 'identifying healthy portion sizes' (n = 103; 58%), 'creating 
 TABLE 7
 Summary of nutrition, cooking and food skill topics of interest for a CM/CN CPD course

	Frequency (n)	Percent
Nutrition topics		
Goal setting for healthy eating	93	52
Behaviour change/health coaching for healthy eating	92	52
Understanding special versus 'fad' diet	90	51
Diet across the lifespan	85	48
Understanding food access and socioeconomic barriers to healthy eating	74	42
Critiquing nutrition information and spotting pseudoscience	52	29
Tips for dispelling nutrition myths with patients	55	31
Other	1	1
Cooking topics		
Simple vegetable dishes for meals, sides and snacks	93	52
Cooking for different cultures	87	49
Cooking with leftovers or limited ingredients	74	41
How to prepare and cook vegetables	70	39
Cooking techniques (e.g., steaming)	61	34
Food preparation and cooking for chronic disease	58	32
Plant based cooking	63	35
Food preparation techniques (e.g., knife skills)	45	25
Food skill topics		
Healthy portion sizes	103	57
Created balanced meals	88	49
Understanding food labels	88	49
Meal planning	83	46
How to select and store vegetables	70	39
Food budgeting	73	41
Healthy meals with limited resources	64	36
Planning meals to minimise environmental impact	45	25

*Note:* Data from participants (n = 180) who reported they were somewhat likely or likely to participate in a CM/CN CPD course if it was NOT a recognised CPD activity by their professional association.

Abbreviations: CM, culinary medicine; CN, culinary nutrition; CPD, continuing professional development.

balanced meals' (n = 88; 49%) and 'understanding food labels' (n = 88; 49%) were the most common skills content requested related to meal planning and food skills (Table 7). BOA The Associ

# DISCUSSION

The present study investigated cooking and food skills, nutrition knowledge, and diet quality of health and education professionals. It also gauged their interest in participating in a course to enhance skills on these topics, at the same time as identifying barriers and facilitators to providing CM/CN behaviour change support as part of providing usual care to their patients, clients, adult learners and students. Overall, moderate cooking food preparation and meal planning confidence, and nutrition knowledge scores were identified. The findings highlight interest in a CM/CN CPD course, particularly if it was recognised as a CPD activity. However, these results indicate a reasonable level of interest exists, even if it was not a recognised CPD activity. A handful of key barriers were identified, with the most relevant modifiable barrier identified in all areas being a lack of knowledge. Although most participants felt that providing health behaviour change education was within their scope of practice, lack of knowledge was the most frequently reported barrier to providing nutrition education and behaviour change education to patients, clients, adult learners and students.

Food preparation and cooking, meal planning and food skills education were identified as outside of scope of practice, even though the majority of participants felt that providing health behaviour change education to their patients was within scope of practice. Practitioners are unlikely to provide education that is not considered to be part of their role.<sup>10</sup> The perception that provision of behaviour change support through opportunistic healthcare is outside of scope of practice is frequently identified as a barrier among health professionals.<sup>7</sup> Programs providing CM/CN health behaviour change education to health and education professionals should include education regarding what advice can be given that is within scope of practice, and when the practitioner should refer patients, clients, adult learners or students to a clinician specialised in nutrition, such as a registered or accredited practising dietitian.

Higher food skill confidence scores were reported for professionals providing cooking and/or nutrition education in a community setting; however, the result was not statistically significant. This was an anticipated result because the criteria for inclusion in this category was provision of cooking and/or nutrition education we would have expected higher food skill confidence scores from education professionals. An online cross-sectional survey of 910 Australian adults found food skills confidence to be a better predictor of diet quality than actual cooking skills.<sup>40</sup> It was highlighted that this may be a result of the broad range of skills required in the provision of healthy meals. This suggests that the use of food skill education within opportunistic healthcare, and CM/CN programs may have potential to improve diet quality. Thus, inclusion of food skill education and

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evaluation in CM/CN programs may be an area of greater priority than cooking skills.

Nutrition knowledge (PKB-7) scores across all professions was low, indicating that nutrition education for both health and education professionals is needed. This is despite the majority of participants reporting that they had received nutrition education as part of their entry-level professional qualification. Although CM/CN CPD activities are available internationally,<sup>21</sup> it has been previously documented that nutrition education provided in undergraduate medical schools and health professional training programs, or as post-graduate CPD is currently insufficient to equip health professionals with the knowledge and skills needed to then effectively empower their patients and clients.<sup>14,15,41</sup> In addition, dietitians may benefit from CPD targeting culinary components of CM/CN programs. The findings of the current survey further highlight the need for a more comprehensive and coordinated approach to nutrition education in medical schools, other healthrelated courses and in CPD programs.

Despite participants identifying food preparation and cooking, meal planning and food skills education as outside their scope of practice a majority still reported being likely to participate in a CM/CN CPD course. Potentially, participants may be more interested in these topics for personal benefits related to their own and/or their families' health. There is potential for CM/CN CPD to address both the barriers of knowledge and skill of the professional and the personal behaviour of the professional. Overall, participants were more likely to partake in a course if there were perceived benefits for their practice, such as accredited professional development. Although it was outside the scope of this survey to examine these motivating factors, future studies or course evaluations may want to consider this in their designs.

Key topics identified for a CPD course included goal setting and behaviour change for healthy eating; understanding special versus 'fad' diets; diet across the lifespan; simple vegetable recipes; cooking for different cultural groups; cooking with limited ingredients or utilising leftovers; portion sizes; balanced meals; and understanding food labels. Therefore, future studies or CPD courses with a focus on these topics and which emphasise health behaviour change education are indicated.

The present study has a several strengths and limitations. Validated measures were used to assess cooking and food skills confidence,<sup>35</sup> nutrition knowledge,<sup>37</sup> and vegetable and fruit intake and variety.<sup>36</sup> We used rigorous methods to ensure only high-quality data responses were included. Health professionals of all levels of experience, based on years practising, were evenly represented in the final sample supporting generalisability across health professionals in different career stages. Limitations included that, although

questions relating to barriers and facilitators to providing nutrition advice in practice were adapted from pretested questions, reliability testing was not conducted. Education professionals were included if they taught either nutrition or cooking, or both, in community or adult education settings. It is possible that our sample captured education professionals working in a broad range of settings, with a range qualifications and prior experience. A range of factors influence cooking, understanding these factors supports planning of cooking education programs tailored to the needs of their recipients.<sup>42</sup> Further research with a larger sample and gathering information about the specific setting and form of cooking and/or nutrition education provided will support this. For practical reasons, it was only possible to include short nutrition knowledge and diet quality questionnaires. Although brief, the PKB-7 is a valid and reliable measure for assessing practical knowledge of nutrition recommendations, further exploration of nutrition knowledge in health and education professionals should be considered. This could potentially be the Revised General Nutrition Knowledge Questionnaire<sup>43</sup> which provides a more detailed exploration of the areas in which nutrition education within future CM/CN programs could be targeted. This could also be used to evaluate effectiveness of CM/CN intervention in specific areas of nutrition knowledge. Similarly, only a brief dietary intake assessment tool (i.e., FAVVA) was used. However, the FAVVA provides a measure of both amount consumed in addition to the variety consumed and higher vegetable and fruit intake and variety are associated with reduced chronic disease risk<sup>44</sup> and healthcare expenditure.<sup>45</sup> Interventions providing CM/ CN education rarely provide education around vegetables and fruits in isolation. Evaluation of overall diet quality in studies evaluating courses to enhance CN skill of health and education professionals is warranted.

# CONCLUSIONS

Professional development to support CM/CN education conducted by qualified nutrition and culinary professionals is needed. CM/CN interventions should focus on overcoming the barriers related to knowledge, and deliver CM/CN education to patients/clients in the context of usual care, as well as within scope of practice. The findings from the current survey highlight specific areas where education for a CM/CN CPD course can be targeted.

#### AUTHOR CONTRIBUTIONS

Clare E. Collins conceived the idea for the study and generated the research question. Roberta C. Asher, Tamara Bucher, Vanessa A. Shrewsbury, Clare E. Collins, Steven Roberts and Annette Meeder contributed to study design and survey development. Roberta C. Asher managed data collection. Roberta C. Asher and Tamara Bucher contributed to data analysis and interpretation. Roberta C. Asher, Jaimee Herbert and Erin D. Clarke drafted the original manuscript. All authors critically reviewed and edited the manuscript. All authors have seen and approved the final version of the manuscript submitted for publication.

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#### **CONFLICTS OF INTEREST**

Two authors (Roberts S, and Meeder A) are affiliated with the funder Rijk Zwaan Australia Pty. Ltd., who contributed to study design and survey development. These two authors had no access to the research data, nor role in data analysis or interpretation. All other authors declare that they have no conflicts of interest.

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NUTRITION ACROSS THE LIFESPAN

# Examining dietitians' knowledge, skills and attitudes regarding working with older adults in residential aged care facilities and home care services: An integrative review

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#### Abstract

**Background:** The Australian 2021 Royal Commission identified that the dietetic workforce needs to grow in size and capacity to support nutrition care in older adults. However, little is known about dietitians' knowledge, skills and attitudes (KSA) regarding working with older adults in residential aged care facilities (RACFs) or their homes. This review describes dietitians' KSA regarding older adults in RACFs and home care services.

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**Methods:** A systematic literature search was conducted in August 2021 to identify studies examining any aspect of dietitians or student dietitians' KSA working in RACFs and home care services. No restrictions were applied to methodological design, language, location or publication year. Studies were assessed for quality using the Johanna Briggs Institute Quality Appraisal Tools. Study findings were analysed thematically using meta-synthesis.

**Results:** All 17 studies that met the inclusion criteria explored dietitians' attitudes towards their role, three studies examined perceived knowledge, although no studies objectively explored dietitians' skill levels. Five themes were developed inductively: (1) recognising their contribution as dietitians; (2) lacking clarity about the boundaries of their role; (3) all team members have a role to play in nutrition care; (4) assumptions and biases about working with older people; and (5) needing to build capacity in the workforce.

**Discussion:** Dietitians have mixed attitudes about working in RACFs and home care services. Future directions include evaluating dietitians' role in RACFs, reviewing education and training and practical opportunities for student dietitians, and assessing the impact of more dietitian support on an older person's dietary intake and nutrition.

#### **KEYWORDS**

aged, attitude, dietitians, home care services, nursing homes, residential facilities

#### Key points

- Dietitians have mixed attitudes about working in residential aged care facilities and home care services.
- There is an opportunity to further explore dietitians' knowledge and skills about working with older adults.

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# INTRODUCTION

The ageing population continues to place demand for older adults requiring care in residential aged care facilities (RACFs) and in-home health care.<sup>1–4</sup> In Australia, the 2021 Royal Commission into Quality and Safety in Aged Care recognised an urgent need to improve services that support Australians to live and age well.<sup>2</sup> Recommendations from the Royal Commission included strengthening the workforce that cares for older adults, increasing employment of allied health professionals in aged care services and ensuring equity of care for older adults living at home.<sup>2</sup>

Dietitians are the only health professionals trained in providing nutrition care to prevent or reduce age-related malnutrition and chronic disease.<sup>5</sup> Through delivery of nutrition interventions, dietitians are able to improve the health and wellbeing of older adults.<sup>6,7</sup> Therefore, they are an important workforce for providing nutrition care in RACFs and in-home services. In response to the Royal Commission, Dietitians Australia recommended that RACFs engage dietitians to provide at least 1 h per month of nutrition care per resident.<sup>8</sup> If this recommendation is to be achieved, the dietetic workforce in aged care needs to increase substantially in size and capacity.<sup>7</sup>

Currently, little is known about dietitians' knowledge, skills and attitudes (KSA) regarding working with older adults in RACFs or their homes. A greater understanding of dietitians' KSA when working with older adults in RACFs or their homes can inform workforce strategies to support capacity-building initiatives that produce quality care. Therefore, the present study aimed to synthesise evidence regarding dietitians' KSA working in RACFs and home care services.

# METHODS

An integrative review was conducted following the methodology of Whitemore and Knafl<sup>9</sup> to examine dietitians working with older adults in RACFs and home care services. An integrative review was chosen as a result of the range of study designs, including qualitative and quantitative studies.<sup>9</sup> The five-stage methodology framework consists of (1) problem identification; (2) a comprehensive search of peer reviewed literature; (3) data evaluation such as study aim, methods, participants, setting, inclusion and exclusion criteria; (4) data analysis using meta-synthesis; and (5) presentation to identify knowledge and evidence gaps to inform future research and practice.<sup>9</sup> The framework enabled the results from various methodologies to be integrated, forming a synthesis of dietitians KSA with older people in these settings, which provides new knowledge to this area of dietetic practice.<sup>9</sup> The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed to report the findings.<sup>10</sup>

### Search strategy

A systematic literature search was conducted in August 2021, with an additional search conducted in January 2022 to capture any new articles. Online databases were searched to identify potentially relevant documents in Scopus, Web of Science, PubMed, CINAHL Complete (EBSCOhost) and Health and Medicine (ProQuest). All of the researchers developed the search strategy with guidance from an experienced health librarian. Literature was searched using the following terms ('dietitian' OR 'dietician' OR 'nutritionist') AND ('nursing home' OR 'nursing facilit\*' OR 'aged care' OR 'long term care' OR 'residential care' OR 'residential facilit\*' OR 'old peoples home' OR 'care home' OR 'retirement home' OR 'retirement facilit\*' OR 'home-based' OR 'home visit' OR 'home care' OR 'home service' OR 'domiciliary service\*' OR 'domiciliary care' OR 'community care' OR 'community service' OR 'outreach service') AND ('knowledge\*' OR 'skill\*' OR 'attitude\*'). In applicable databases, the following MeSH terms were applied ('Home Care Services' OR 'Nursing Homes' OR 'Home Nursing' OR 'Long-Term Care' OR 'Community Health Services' OR 'Residential Facilities').

### Study criteria

#### Inclusion criteria

Studies were eligible for inclusion if they examined any aspect of participants (dietitians, student dietitians or nutritionists) KSA regarding working in RACFs and home care services with older adults (> 65 years). RACFs encompassed nursing home facilities, long-term care facilities, residential care or facility, 'old people's homes', care homes and retirement homes or retirement facilities, as well as care provided via home visits or domiciliary services to older (> 65 years) ambulatory patients living in the community. No restrictions were applied to methodological design, language, geographical location or year of publication. The review did not include rehabilitation or respite settings because they are often associated with a hospital service. Studies were excluded if data on dietitians could not be separated from other health professionals, such as nursing staff. Studies where the aged care or community dietitian data could not be isolated from dietitians working in other settings (e.g. hospital-based dietitians) were also ineligible for inclusion.

### Types of evidence

All articles were imported from the databases into Endnote (https://endnote.com) and duplicates were removed. The remaining articles were exported into

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Covidence (https://www.covidence.org), which is an online tool that streamlines parts of the review process). Within Covidence, study titles and abstracts were screened independently in duplicate. One researcher (KB) screened all titles and abstracts, and two other members of the research team (LB and RR) shared the screening of all titles and abstracts. The research team comprised three academic dietitians and an academic nurse. One dietitian has experience working in residential aged care and home care settings, and the registered nurse is gerontological trained with clinical experience in residential aged care. Full-text articles were screened in duplicate independently against the selection criteria by KB and RR. Articles not in English were sent to bilingual colleagues for translation. Finally, the reference lists of all included studies were hand-searched for any additional relevant studies.

#### Data charting process and items

Data from the identified studies were extracted within Covidence using a predesigned template. Data were extracted by one researcher (KB) and checked for accuracy by a second researcher (LB). Data included article details and characteristics (e.g., author, year, country of origin), study design (e.g., qualitative or quantitative, cross-sectional or longitudinal study), participant characteristics of the dietitian (e.g., the number of participants) and older adults (e.g., age and settings such as RACFs and in home care), methodology (including recruitment, methods, e.g., survey, interview, focus group), and both qualitative and quantitative data exploring dietitians' KSA working in RACFs and home care services. Three researchers (KB, RR and LB) reviewed and discussed discrepancies in the extracted data for consensus.

#### Quality appraisal

The Johanna Briggs Institute Checklist for Qualitative Research<sup>11</sup> and Checklist for Analytical Cross-Sectional Studies<sup>12</sup> were used to assess the methodological quality of the studies and whether any bias may exist within study design, conduct and analysis. The qualitative checklist included 10 questions with *yes*, *no*, *unclear* and *non-applicable* response options and a final overall appraisal question with responses including *include*, *exclude* and *seek further information*. The quantitative cross-sectional checklist included eight questions with the same response options as the qualitative response and the same overall appraisal question. The studies were appraised in duplicate (KB and RR) and, if any discrepancies arose, a third researcher (LB) was involved.

#### Data synthesis

Data from studies were analysed thematically using meta-synthesis. Meta-synthesis offers a novel finding through integrative interpretation of the results of each study reviewed.<sup>13</sup> Data were analysed using an iterative comparison of studies to identify reoccurring themes and subthemes.<sup>9</sup> Findings of the studies were independently read several times, placed into a table, and then compared across the studies to identify relationships, themes and subthemes.<sup>9</sup>

#### RESULTS

#### Overview

The PRISMA flow diagram is shown in Figure 1. Initially, 7985 studies were screened by title and abstract and, of these, 639 studies were screened using their fulltext version. Seventeen studies (comprising of dietitians, n = 2635; student dietitians, n = 9) met the inclusion criteria, and study details are reported in Table 1. Studies comprised of descriptive and analytical cross-sectional designs. Methods included surveys (n = 10), 14-18,20-22,24,28interviews  $(n=6)^{19,25-27,29,30}$  and focus group  $(n=1)^{.23}$ Participant numbers ranged from  $n = 1^{25}$  to n = 1281.<sup>15</sup> Twelve studies included dietitians in RACFs and five studies explored dietitians working within home care services and studies were published between 1986<sup>18</sup> to 2021.<sup>27</sup> The location of the studies were conducted in the USA (n = 6), <sup>15,18–20,22,28</sup> Canada (n = 3), <sup>14,26,29</sup> Australia (n = 2), <sup>16,24</sup> UK (n = 2), <sup>23,25</sup> Israel (n = 2), <sup>17,27</sup> Japan  $(n=1)^{21}$  and the Netherlands  $(n=1)^{30}$ 

All studies all explored dietitians' attitudes towards their role, three studies examined perceived knowledge, although no study objectively measured dietitians' skill levels. Knowledge and attitudes were investigated in relation to the role of dietitians (n = 7),<sup>15,18–20,22,28,29</sup> malnutrition/undernutrition screening or management (n = 4),<sup>16,23,24,30</sup> challenges or changes to practice (n = 2),<sup>14,27</sup> factors affecting the nutrition status of older adults (n = 2),<sup>17,25</sup> student dietitians' experience providing meal assistance  $(n = 1)^{26}$  and conduct of home visit services (n = 1).<sup>21</sup>

The methodological quality of studies is reported in Table 2. Quantitative studies scored 'yes' to  $2/8^{21}$  to  $6/8^{20,24}$  criteria; qualitative studies scored 'yes' to  $2/10^{22}$  to  $10/10^{26}$  criteria. Quality ratings for quantitative studies were reduced primarily as a result of not clearly defining the inclusion criteria, the exposure not measured validly and reliably, and confounding factors were not identified. Quality rating deductions for qualitative studies included a lack of congruity with the philosophical perspective and research methodology, no statement addressing any research influence on the research or locating the researcher culturally or theoretically.

**FIGURE 1** Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of included studies



All studies were included irrespective of methodological quality checklist scores as a result of the paucity of literature available.

# Meta-synthesis

Five themes were developed inductively: (1) recognising their contribution as dietitians; (2) lacking clarity about the boundaries of their role; (3) all team members have a role to play in nutrition care; (4) assumptions and biases about working with older people; and (5) needing to build capacity in the workforce.

# Recognising their contribution as dietitians

The first theme highlighted dietitians' strong sense of value in contributing to RACFs and home care services. Dietitians reported taking their role in aged care 'seriously'<sup>26,29</sup> and recognised the distinct value of their role within clinical care teams.<sup>26,29</sup> In one study where student dietitians provided practical feeding support to residents in RACFs, students expressed they undertook their activities to a high standard in the pursuit of providing autonomy and dignity to the older adults they were caring for.<sup>26</sup> Student dietitians valued the

opportunity to gain experience in the sector, not just for future employability but because of the apparent positive impact their actions had on fellow staff and patients.<sup>26</sup>

# Lacking clarity about the boundaries of their role

The second theme emphasised dietitians' perceived lack of role clarity working in RACFs and home care services. Dietitians described their roles and tasks as variable, everchanging and multi-faceted, to the extent that their role may be unclear to others.<sup>29</sup> For example, one dietitian recalled that their facility manager once asked, *Can I get a list of what (services) you provide?*<sup>29</sup> Other dietitians explained their tasks as mostly 'self-appointed' or 'self-directed', with one dietitian reporting, 'I always make my job ... there has never been a job description for me and ... I have never been trained for a job, ever'.<sup>29</sup> Several other studies supported the notion of lack of clarity for dietetic roles, as each study described different role functions, including providing nutrition care, working with food service, completing in-service education for staff and maintaining and conducting quality assurance audits.<sup>18–20,27–29</sup> Dietitians also perceived a difference between actual and desired tasks, specifically that

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First author surname (year) Country	Study design and method	Relevant aim <sup>a</sup>	Focus of study	Participants (sample size), setting	KSA element discussed
Quantitative <sup>a</sup>					
Black et al (2013) <sup>14</sup> Canada	Cross-sectional online survey	To explore current practices and workforce related issues amongst LTC dietitians	Challenges for LTC dictitians	Dictitians ( $n = 75$ ) nursing homes	Attitudes
Chao et al (2008) <sup>15</sup> USA	Cross-sectional survey	To learn whether registered dietitians working in assisted-living facilities rate the Food and Nutrition Care Indicators Checklist <sup>b</sup> as highly important	Opinions on food and nutrition care indicators	Dictitian ( $n = 1281$ ) nursing homes	Attitudes
Craven et al (2016) <sup>16</sup> Australia	Cross-sectional online survey	To explore malnutrition screening practices by dictitians working in the community setting	Malnutrition screening	Dictitians ( $n = 133$ ) home	Attitudes
Endevelt et al (2007) <sup>17</sup> Israel	Cross-sectional survey	To explore Maccabis' dietitians' attitudes and knowledge regarding elderly nutrition	Elderly nutritional factors	Dictitian $(n = 95)$ nursing homes	Attitudes, perceived knowledge
Finley and Simons (1986) <sup>18</sup> USA	Cross-sectional survey	To identify and compare perception of the role of the consultant dietitians dietitian in the nursing homes in Iowa by consultant dietitians	Role perceptions	Dictitians ( $n = 69$ ) nursing homes	Attitudes
Finn et al (1991) <sup>19</sup> USA	Cross-sectional phone interview	To determine the image and activities of consultant dietitians in LTC	Image and role of dietitians	Dictitian $(n = 328)$ nursing homes	Attitudes, perceived knowledge
Gilbride and Simko (1986) <sup>20</sup> USA	Cross-sectional survey	To describe the functions of a dictitian's role as perceived by dictitians and to examine the level of consensus among dictitians about the importance of each of the role functions	Role functions of dictitians	Distitians: full time $(n = 200)$ part time $(n = 125)$ nursing homes	Attitudes
Hirakawa et al (2003) <sup>21</sup> Japan	Cross-sectional survey	To understand the current home visit system and identify any barriers to the spread of the system	Home care services	Dictitians ( $n = 129$ ) home	Attitudes and perceived knowledge.
Welch et al $(1988)^{22}$ USA	Cross-sectional survey	To describe the amount and adequacy of time spent by consultant dietitians in role functions and to identify foodservice and nutrition care problems in nursing homes	Time in role functions and foodservices and nutrition care problems	Dictitians ( $n = 43$ ) nursing homes	Attitudes
Qualitative					
Avgerinou et al (2020) <sup>23</sup> UK	Cross-sectional focus group	To explore the views and practices of dietitians on the management of malnutrition in frail older people	Malnutrition management	Dictitian $(n = 2)$ home	Attitudes
Beelen (2017) <sup>24</sup> Netherlands	Cross-sectional interviews	To better understand how protein-enriched products would fit in the current treatment of undernutrition	Treatment of undernutrition	Dictitians ( $n = 3$ ) nursing homes	Attitudes
Craven et al (2017) <sup>24</sup> Australia	Cross-sectional survey	To identify dietitians' barriers and enablers to malnutrition screening of community living older adults	Malnutrition screening	Dictitians $(n = 92)$ home	Attitudes
Mole et al (2019) <sup>25</sup> UK	Cross-sectional interview	To understand the experiences and perspectives relating to nutritional care of health care professionals and home care workers, who interact with people living with dementia at home	Nutritional care for people living with dementia	Dictitian $(n = 1)$ home	Attitudes
Osinga and Keller (2013) <sup>26</sup> Canada	Cross-sectional interview	To examine dietetic students' experiences who volunteered or were paid meal helbers in Ontario 1 TC homes	Experiences providing meal assistance	Student dictitians $(n = 9)$ nursing homes	Attitudes

TABLE 1 Studies (n = 17) exploring dictitians' knowledge and attitudes of working with older adults in RACFs and home care services

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ment discussed	s, perceived wledge	S	S	
KSA ele	Attitude knov	Attitude	Attitude	
Participants (sample size), setting	Dictitians ( $n = 18$ ) nursing homes	Dietitians ( $n = 30$ ) nursing homes	Dietitians ( $n = 11$ ) nursing homes	
Focus of study	Change to practice (about new nutrition-focused physical examination)	Role functions of dietitians	Perspectives of their role and identifying success-related factors	
Relevant aim <sup>a</sup>	To explore dictitians' experience of nutrition-focused physical examination-oriented° change and its implementation into their routine practice	To understand role functions, attitudes and perceptions of dietitians working in LTC homes	To gain insight into LTC dietitians' experience of clinical practice	des; LTC, long-term care; RACFs, residential aged care facilities. studies to provide overview of data extracted.
Study design and method	Cross-sectional interview	Cross-sectional survey	Cross-sectional interview	edge, skills and attitu dapted from included
First author surname (year) Country	Sheffer-Hilel et al (2021) <sup>27</sup> Israel	Suarez and Curry (1989) <sup>28</sup> USA	Wassink and Chapman (2010) <sup>29</sup> Canada	Abbreviations: KSA, know <sup>a</sup> Relevant aim: aims were ad

Food and Nutrition Care Indicators Checklist: Food and Nutrition Care Indicators Checklist indicator for evaluating food and nutrition services

Nutrition-focused physicals examination: the assessment of patients' nutritional status based on a physical examination of oral health

spending time with patients was a high priority but not always possible because of their other duties.<sup>18,28</sup> Dietitians' lack of role clarity contributed to concerns about how other team members perceive their role. One dietitian expressed '*I have so many areas of responsibility* 

that I am not good at anything ... it's very frustrating'.<sup>27</sup> These concerning attitudes have persisted over time, with one survey in the year 1989 finding that most (n = 22; 73%) participants were frustrated in their role, some (n = 9; 30%) felt depressed about their role, and half (n = 15; 50%) were satisfied in their role.<sup>28</sup> More recently, dietitians rated other professions higher than their own regarding their position being viewed as 'necessary/vital/ important' and 'helpful and cooperative'.<sup>19</sup>

# All team members have a role to play in nutrition care

The third theme focuses on dietitians' view that all staff in RACFs and home care services can influence the nutrition status of older adults and therefore have a role to play in nutrition care. Dietitians acknowledged that it is not just the role of dietitians to deliver nutrition care and implement nutrition plans or interventions.<sup>17,25</sup> One study described nutrition as a 'team effort' and further emphasised that 'nutritionists are totally ineffective without nursing behind them', stemming from the lower workforce size and subsequent capacity of dietitians.<sup>29</sup> Dietitians recognised the importance of teamwork; however, they did not feel that all team members supported the role of dietitians in providing nutrition care. For example, dietitians perceived that referrals were not always timely<sup>30</sup> or requested.<sup>21</sup> In a survey study, dietitians reported that team members did not feel they had sufficient time to contribute to nutrition care,<sup>28</sup> which would burden their work.<sup>24</sup> In addition, dietitians faced challenges to the timely provision of nutrition care, including lack of anthropometric or biomedical data<sup>22</sup> and other staff feeling 'undertrained' in nutrition considerations.<sup>28</sup> Dietitians also expressed they were not respected and were not well utilised to meet patient needs.<sup>28</sup> In the focus groups conducted by Avgerinou *et al.*,<sup>23</sup> dietitians expressed needing to overcome misinformation that patients received from other team members, which was sometimes perceived as inconsistent and non-evidence-based. As such, dietitians highlighted the potential positive impact of additional education and training on nutrition for all health professionals and team members, which would support dietitians in carrying out their role to a high standard.<sup>22,24</sup>

# Assumptions and biases about working with older people

The fourth theme highlighted dietitians' assumptions and biases about working with older people. In a survey of

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TABLE 2 JBI critical appraisal checklist for analytical cross-sectional studies (n = 9) and qualitative research (n = 8)

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First author (year)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total <sup>a</sup>	Overall appraisal include
<i>Quantitative</i> <sup>b</sup>												
Black et al (2013) <sup>14</sup>	Y	Y	N/A	Y	N/A	N/A	Y	Y	-	-	5	1
Chao et al (2008) <sup>15</sup>	Y	Ν	N/A	Y	Ν	N/A	Y	Y	-	-	4	1
Craven et al (2016) <sup>16</sup>	Y	Y	N/A	Y	Y	Ν	Y	Y	-	-	6	1
Endevelt et al (2007) <sup>17</sup>	Ν	Y	N/A	U	Y	Y	Y	Y	-	-	5	1
Finley and Simons (1986) <sup>18</sup>	Y	Y	N/A	Y	Ν	N/A	Y	Y	-	-	5	1
Finn et al (1991) <sup>19</sup>	Y	Ν	N/A	U	Ν	N/A	Y	Y	-	-	3	1
Gilbride and Simko (1986) <sup>20</sup>	Y	Y	N/A	Y	Y	Ν	Y	Y	-	-	6	1
Hirakawa et al (2003) <sup>21</sup>	Ν	Y	N/A	Y	Ν	N/A	U	N/A	-	-	2	1
Welch et al (1988) <sup>22</sup>	Ν	Y	N/A	Y	Y	Ν	Y	Y	-	-	5	1
Qualitative <sup>c</sup>												
Avgerinou et al (2020) <sup>23</sup>	Ν	Y	Y	Y	Y	Y	Ν	Y	Y	Y	8	1
Beelen (2017)	Ν	Y	Y	Y	Y	Y	Ν	U	Y	Y	7	1
Craven et al (2017) <sup>24</sup>	Ν	Y	Y	Y	Y	Ν	Ν	Y	Y	Y	7	1
Mole et al (2019) <sup>25</sup>	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	1
Osinga and Keller (2013) <sup>26</sup>	Y	Y	Y	Y	Y	Ν	U	Y	Y	Y	8	1
Sheffer-Hilel et al (2021) <sup>27</sup>	Y	Y	Y	Y	Y	Ν	Ν	Y	Y	Y	8	1
Suarez and Curry (1989) <sup>28</sup>	Ν	U	U	U	U	Ν	Ν	Y	Ν	Y	2	1
Wassink and Chapman (2010) <sup>29</sup>	Y	Y	Y	Y	Y	U	Ν	Y	Y	Y	8	1

Abbreviations: JBI, Johanna Briggs Institute; N, no; N/A, not applicable; Q, question; U, unclear; Y, yes.

<sup>a</sup>Total number of 'Yes' responses.

<sup>b</sup>JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies — Q1: Were the criteria for inclusion in the sample clearly defined? Q2: Were the study subjects and the setting described in detail? Q3: Was the exposure measured in a valid and reliable way? Q4: Were objective, standard criteria used for measurement of the condition? Q5: Were confounding factors identified? Q6: Were strategies to deal with confounding factors stated? Q7: Were the outcomes measured in a valid and reliable way? Q8: Was appropriate statistical analysis used?

<sup>c</sup>JBI Critical Appraisal Checklist for Qualitative Research — Q1: Is there congruity between the stated philosophical perspective and the research methodology? Q2: Is there congruity between the research methodology and the research question or objectives? Q3: Is there congruity between the research methodology and the methods used to collect data? Q4: Is there congruity between the research methodology and the research report flow from the analysis, or interpretation, of the data?

1281 dietitians, only half of the dietitians (53%) perceived older people 'would be able to make wise dietary choices on their own but that they needed education and counselling'.<sup>15</sup> Very few (31%) thought older adults could '... make dietary choices on their own without assistance', and some (16%) thought that older adults were 'unable to make dietary choices on their own'.<sup>15</sup> A similar finding occurred through a survey from Israel, with almost half (49.5%) of the dietitians strongly disagreeing that older people 'can't change their nutritional habits', whereas 24% slightly agreed that older people could not change their nutritional habits.<sup>17</sup> Furthermore, a cross-sectional survey, reported differences in how dietitians described older people, with some dietitians stating they're 'lovable and fun', yet others defined them as 'irritable, pitiable, and *confused*<sup>28</sup> These papers suggest that dietitians have assumptions and biases about older people, including their ability to make positive changes to their diet, the amount of nutrition education and counselling they require, and their overall demeanour.

#### Needing to build capacity in the workforce

The fifth theme highlighted a clear need to increase RACFs and in-home care services' workforce capacity because dietitians reported a lack of time, funding and professional development opportunities. Dietitians reported insufficient time to complete required tasks.<sup>14</sup> Concern over workforce capacity has persisted over time,
with a cross-sectional study in 1988 suggesting that 74% of dietitians in their study had insufficient time spent within the nursing home to fulfil professional responsibilities.<sup>22</sup> Dietitians also mentioned workload difficulties because of a lack of time, human resources and increased workload.<sup>27</sup> In five studies, dietitians suggested that more job opportunities are needed in RACFs and home care services.<sup>16,19,21,25,27</sup> A dietitian also mentioned a shortage of employment positions for dietitians in an interview conducted in Israel; 'Unfortunately ... the current standardisation (hours and workload requirements) doesn't allow me to work to the extent and quality I would *like*<sup>27</sup> Furthermore, dietitians perceived that the organisations or businesses that commission the services do not allocate sufficient paid time to monitor their patients effectively.<sup>19,25</sup> Dietitians also shared a lack of confidence as some reported fewer positive responses about their knowledge in general compared to other health professionals.<sup>1</sup>

Dietitians reported they need to build knowledge with new tasks and highlight that they need time to develop professionally.<sup>27</sup> Despite a perceived lack of knowledge around new tasks and poorer ratings of perceived knowledge, 63% of dietitians rated their overall perceived knowledge about older adult nutrition as 'good'.<sup>17</sup> Furthermore, dietitians revealed that they lack professional development opportunities to improve this knowledge.<sup>27</sup> The barriers to knowledge development described by dietitians can negatively impact on dietitianpatient relationships and the dietitians' ability to improve the patient's quality of life.<sup>27</sup>

#### DISCUSSION

This integrative review synthesised a modest body of literature on dietitians' knowledge and attitudes regarding working with older adults in RACFs and home care services. Collectively, this review contributes to the small amount of literature about dietitians working with older adults in RACFs and their homes. Dietitians and student dietitians recognised their contributions to the clinical care team and took their role seriously in RACFs. The review did not include any studies with nutritionists or explore any aspect of dietitians or student dietitian skills as a result of an absence of literature.

Dietitians reported challenges understanding the boundaries of their role working with older adults. Lack of role clarity is consistent in a recent study by Hickson et al.<sup>31</sup> where dietitians revealed desire for visibility, role clarity and future growth. Dietitians Australia released a role statement for RACF dietitians in July 2021 to provide consensus and clarity.<sup>32</sup> This role statement provides dietitians and other health professionals with a comprehensive list of knowledge and skills expected of dietitians working in RACFs.<sup>32</sup> The dissemination and implementation of the role statement have not been

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formally evaluated and should be considered in the future. Additionally, a role statement for dietitians working in-home care services may provide similar clarity to dietitians and other staff members. Enhanced role clarity by integrating interprofessional education and clarity throughout organisations is imperative to reduce staff burnout, increase retention, and ensure the delivery of quality and safe care.<sup>33</sup>

Dietitians heralded that all team members have a role in nutrition care. However, limited involvement of staff in nutrition care in RACFs has been reported in a crosssectional survey study by Beattie et al.<sup>34</sup> This survey revealed that 83% of nursing, personal care, catering and therapy RACF staff considered nutrition care and assessment important despite lacking nutrition knowledge (with a mean score of 47%) and only 53% reported carrying out nutrition activities.<sup>34</sup> Furthermore, a 2020 systematic review on malnutrition practices in older adults revealed that other health professionals' time for, and knowledge of, screening policies is inadequate and negatively affects the impact of dietitians.<sup>35</sup> Cave et al.<sup>36</sup> highlighted that teamwork between all staff is required to encourage adequate dietary intake in older adults. The lack of nutrition knowledge and prioritising nutrition care was also a key finding of the 2021 Royal Commission into Quality and Safety in Aged Care in Australia.<sup>2</sup> As such, the findings of this integrative review support Dietitians Australia recommendation to review and update certificate courses for RACF care staff to include a component of nutrition to their education to enhance knowledge.<sup>37</sup> Including nutrition in these courses could increase knowledge and skills relating to nutrition care for older adults,<sup>37</sup> thus enhancing the nutrition status and health outcomes of this important population.

Dietitians appear to have assumptions and biases regarding older people. Assumptions and biases of older people and aging are not uncommon amongst health care professionals and have been well documented in the literature.<sup>38,39</sup> Stereotypes go beyond the older person and can also relate to the setting. Lordly and Taper<sup>40</sup> mixed-methods survey study revealed that dietitians have negative attitudes towards being trained and/or working in long-term care. It was revealed that long-term care dietitians feel 'lesser' than acute care dietitians.<sup>40</sup> Negative attitudes about working in these settings are consistent with two survey studies revealing low work preferences for student dietitians working with older people.<sup>41,42</sup> Students reported concerns and fears about working with older people.<sup>41</sup>

To minimise these negative assumptions and biases, interventions targeting the student experience and knowledge need to be developed. For example, increasing exposure through placements, volunteering, work experience or a guided experiential assignment<sup>43</sup> and providing adequate undergraduate theory on nutrition for older people could reduce these assumptions and

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biases in future dietitians. Strengthening the RACF and home care workforce for dietitians may assist in optimising attitudes and encouraging more dietitians to work in these settings. Healthcare systems need to continue to work toward patient centred anti-ageism care and ensure all older people have access to care,<sup>38</sup> including dietitian services. A key area to provide education and initiative to reduce ageism is through universities where future health professionals are trained.<sup>38</sup>

Dietitians highlighted the need for building capacity through more funding, time and professional development opportunities for dietitians working in RACFs and home care services. The identified workforce capacitybuilding areas are consistent with the recent 2021 Royal Commission into Quality and Safety in Aged Care in Australia findings of allied health professionals.<sup>2</sup> Based on the Royal Commission recommendations, Dietitians Australia also advocates for dietitians to see all residents for 1 h per resident, each month in RACFs and increase older persons' access to dietitians' within home care settings.<sup>8</sup> A 2016 survey of 150 long-term care dietitians in Ontario, Canada revealed that 89% of dietitians could not complete all required responsibilities within the mandated Registered Dietitian staffing time of 30 min per resident per month.<sup>44</sup> By increasing time at RACFs to a recommended 45 min per resident per month, dietitians reported that it would allow for more timely follow-ups on clinical issues, communication with residents and families, interprofessional communication, staff education, quality improvement activities and other proactive roles.<sup>44</sup> Despite this survey's results encouraging the increase in mandated hours, the mandated ratio in Ontario has remained unchanged. Additional time could allow for more opportunities to build capacity in the workforce. As such, future research needs to examine the impact of additional dietetic time on older adults' dietary intake, health outcomes and economic evaluation of this service. Moreover, continuing to advocate for dietitians to be employed full-time in RACFs and patients having more access to home care dietitians will allow for ongoing support from the dietitian and the opportunity for in-service training for all staff.

Dietitians' actual knowledge and skills were not synthesised from this review because they were not objectively measured in the original research studies. Although one study provided insight into the perceived knowledge of dietitians, which is consistent with previous surveys exploring actual knowledge,<sup>41,42</sup> it is important to recognise that actual and perceived knowledge may not always be congruent.<sup>45</sup> Perceived knowledge is an individual's assessment of the knowing information; as such, individuals may overestimate, underestimate or accurately rate their perceived knowledge following actual knowledge. In addition, perceived knowledge often depends on individual variables (such as selfesteem and self-monitoring) and contextual variables (such as topic area and nature of information). Therefore, it is an important consideration when accessing actual knowledge. Thus, a dietitian's knowledge (both perceived and actual) and skills about working in RACFs and home care settings is required to understand the knowledge and skills gap to target further education and training to current and upcoming dietitians. Further research is needed to understand dietitians' knowledge and skills of dietitians working in RACFs and home care settings to ensure dietitians provide optimal nutrition care to all patients.

There are notable strengths and limitations of the review. A strength of this review is the variety of designs in 17 studies. The range of methodological designs and objectives provides a broad overview of dietitians' attitudes and some insight into perceived knowledge working in RACFs and home care. The quality of this review has been maximised at all stages of the review by using systematic and rigorous processes. The processes undertaken include two independent researchers screening title and abstract and full text, cross-checking all elements of data extraction, and a third reviewer's availability to assist if any discrepancies arise. The methodological process used was to reduce any bias and potential complexities associated with the synthesis of qualitative and quantitative findings. The strength of using the iterative process of meta-synthesis allowed identification of emerging themes, which were reviewed and revised by all of the investigators. However, the methodological quality, language of study and date of publications of studies were not a criterion for inclusion or exclusion. Thus, the results of this review must be interpreted with caution as it includes lower-quality studies, a translated article and older studies. Additionally, the findings were often reported in context to a particular component or area of RACFs and home care services, such as malnutrition management or role functions of dietitians. Explicating examining dietitians' attitudes working in these settings may elicit different results.

#### CONCLUSIONS

Dietitians recognised the important contribution of their role to caring for older adults; however, they experience low clarity about the boundaries of their role. Dietitians appear to have positive and negative assumptions and biases about older people. Moreover, dietitians have recognised issues in the workforce, with not all team members prioritising nutrition care despite dietitians recognising all members have a role. Dietitians recognised that the dietetic workforce needs to build capacity. Additional research is needed to understand dietitians' knowledge and skills regarding working in RACFs and home care services to provide insight into future research and initiatives. Future directions could include evaluating dietitians' role in aged care, reviewing education and training and practical opportunities for student dietitians, and assessing the impact mandated dietitian hours have on an older person's dietary intake and nutrition.

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#### **CONFLICTS OF INTEREST**

Lauren Ball is on the editorial board for the *Journal of Human Nutrition and Dietetics*.

#### AUTHOR CONTRIBUTIONS

Karly Bartrim contributed to the conception and design of the research, the collection and analysis of the data, and created the original draft and reviewed and edited subsequent versions. All authors contributed to the design of the research, to the analysis and interpretation of the data, and to writing, reviewing and editing. All authors approved the final version of the manuscript submitted for publication. All authors declare that the content of the manuscript has not been published elsewhere.

#### 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 have been explained. The review was not registered.

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NUTRITIONAL SUPPORT AND ASSESSMENT

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## Development of a nutrition screening tool to identify need for dietetic intervention in female infertility

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#### Abstract

Background: One in seven couples are impacted by infertility in the UK, and female infertility is often associated with several health conditions impacted by nutrition. Despite many studies aimed at identifying the critical role of nutrition in infertility, there is currently no screening tool that identifies nutritional risk factors for infertility.

Aim: To propose a self-administered screening tool to identify women who would benefit from nutritional intervention to promote fertility.

Methods: A narrative review was carried out to identify and summarise modifiable nutritional risk factors that can influence female fertility, including comorbidities that can influence nutrition intake, absorption, and metabolism. Key Findings: A nutrition screening tool outlining modifiable nutrition risk factors potentially improving female fertility has been proposed, comprising of BMI, medical history and quality of diet and lifestyle which would aid in designing evidence based dietetic services for female infertility.

#### **KEYWORDS**

artificial fertility treatments, diet, dietitian, female infertility, nutrition, screening tool

#### The key points from the paper

Nutrition plays a critical role in managing infertility; however, there is currently no screening tool that identifies nutritional risk factors for infertility. We identify and summarise modifiable nutritional risk factors influencing female fertility and propose a self-administered screening tool to identify women who would benefit from nutritional intervention to promote fertility.

#### **INTRODUCTION**

The prevalence of infertility in the UK is approximately 1 in 7 couples,<sup>1</sup> with an increased prevalence associated with later cohabitation with a partner, higher socio-economic status, higher educational attainment, higher occupational status, and for those with children, becoming parents at an older age.<sup>2</sup> UK live birth rates are declining with 681,560 live births in 2020, a reduction of 4.4% from 2019 and the lowest number of live births since 2002.<sup>3</sup> In addition to increasing age of conception, fertility health care professionals (HCPs) face further issues in the UK, including Clinical Commissioning Groups (CCGs) cutting funding for fertility treatments available through the National Health Service (NHS). Curbs in funding will promote further health inequalities between those able to afford private treatment and those who cannot self-fund their fertility treatment. Few NHS services offer dietetic support within fertility services. When support exists, the focus is mainly on weight management.

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Despite many studies identifying the critical role of nutrition in infertility, there is currently no screening tool that identifies nutritional risk factors for infertility. Given the increasing evidence of the impact of nutrition on infertility, it is timely and essential to develop evidence-based pathways and education materials promoting optimal nutritional status for those seeking support with both natural and artificial reproductive therapies.

#### AIMS AND OBJECTIVES:

Within this article we will be outlining the health conditions, nutritional risk factors, and lifestyle factors linked to infertility which can be positively impacted by nutritional intervention.

This narrative review aims to:

- identify and summarise modifiable nutritional risk factors which can influence female fertility (including comorbidities that can influence nutrition intake, absorption, and metabolism),
- discuss the outcomes achieved by nutritional intervention, and
- propose a screening tool to identify women who would benefit from nutritional interventions to promote fertility.

#### Health Conditions Which Can Be Nutritionally Optimised to Improve Fertility

Female infertility may be associated with several health conditions impacted by nutrition (summarised in Figure 1); their appropriate medical and nutritional management can help improve fertility and other associated health outcomes. This clinical consideration would help HCPs manage beyond the immediate reproductive needs and consider overall health and long-term implications.<sup>4</sup> Examples include the following.

#### Weight and Infertility

Obesity is a well-documented risk factor for infertility and birth complications; and, being underweight is also linked to poorer fertility and birth outcomes. Chavarro et al. (2007) found a J-shaped relationship between weight and infertility due to ovulatory disorders. Women with a body mass index (BMI) >  $25 \text{ kg/m}^2$  and  $< 20 \text{ kg/m}^2$ had a higher risk of infertility, which increased further when BMI was  $>30 \text{ kg/m}^{2.5}$  Van der Steeg et al. (2017) demonstrated that women with a BMI >  $29 \text{ kg/m}^2$ experienced lower fecundity, with the probability of conception linearly declining with each increased BMI point.<sup>6</sup> National Institute for Health & Care excellence (NICE) guidelines suggest that women with a BMI of  $30 \text{ kg/m}^2$  or more should be informed that (i) they are likely to take longer to conceive; (ii) if they are also not ovulating, then losing weight (5-7% body weight) is likely to increase their chance of conception; and (iii) they are likely to have reduced chances of success with assisted reproductive procedures.<sup>7</sup>

A recent systematic review and meta-analysis evaluated the effectiveness of weight management interventions in infertility and found that a reduced-calorie diet and increased aerobic exercise improved pregnancy rates and ovulation status. The authors highlight that the dietary intervention should not be overly restrictive and would be more effective with regular, long-term support (e.g. weekly coaching for 6 months) to improve compliance, with better adherence seen with the dual enrolment of patient and partner.<sup>8</sup>

The highest risk of infertility is seen in women with  $BMI < 20 \text{ kg/m}^{2.5}$  Amenorrhoea (the absence of menstruation) and menometrorrhagia (excessive uterine bleeding) are seen more frequently in women with a



FIGURE 1 Summary of health conditions which can be nutritionally optimised to improve fertility

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low BMI,<sup>9</sup> with a low BMI also linked to poor oocyte guality.<sup>10</sup> Functional hypothalamic amenorrhoea (FHA) is a leading cause of secondary amenorrhoea, the three main types being related to weight loss, stress, or exercise.<sup>11</sup> The US Endocrine Society Clinical Practice Guidelines recommend that the minimum threshold for a woman's BMI be  $18.5 \text{ kg/m}^2$  to optimise her chances of fertility.<sup>12</sup> They suggest that increasing body weight can improve regular ovulation, conception, and uncomplicated pregnancy; this should be done by detailed assessment and counselling by a registered dietitian.<sup>12</sup> NICE guidelines suggest that increasing body weight is likely to improve the chances of conception of women with a BMI <  $19 \text{ kg/m}^2$  with irregular menstruation.<sup>13</sup>

#### Eating Disorders

The importance of dietetic support during weight loss is evidenced by the four-fold higher prevalence of eating disorders (ED) among women with infertility.<sup>14</sup> Given the benefits of a healthy BMI and with fertility centres focusing on weight loss as part of their eligibility criteria, some women will 'diet' – with the intention of weight loss but without adequate advice and support. This can increase their risk of disordered eating or an eating disorder (ED), which are often undetected or untreated. EDs are associated with high-risk pregnancies and complications such as preterm delivery, low birth weight, intrauterine growth restriction, caesarean birth, low Apgar scores, and negative impacts on IVF outcomes.<sup>14</sup> Prevalence of EDs within infertile women is between 5.5% and 20.7%,  $^{14-17}$  particularly in those with ovulatory disorders. In addition, a tendency towards nondisclosure of their ED to their healthcare provider emphasises the need for ED screening.<sup>16</sup>

NICE guidelines suggest that in women with a history of EDs planning a pregnancy, the GP/midwife should advise on healthy eating and avoiding any unhealthy weight loss measures.<sup>18</sup> It is also essential to consider psychological input when indicated<sup>18</sup>; therefore HCPs managing infertility should be proficient in identifying signs of EDs and refer to specialist services when required.

#### Polycystic Ovary Syndrome

Polycystic ovary syndrome (PCOS) is one of the most common endocrine conditions among women of childbearing age, with a prevalence of 2.2%-26%.<sup>19</sup> It is characterised by two or more of the following: hyperandrogenism, anovulation, and polycystic ovaries. A crucial metabolic complication of PCOS is insulin resistance (IR) which is thought to be a pivotal contributor to the pathogenesis, with 40%-70% of women with PCOS having IR independent of BMI.<sup>20</sup> Around 40%–60% of women with PCOS live with obesity, which itself leads to insulin insensitivity, metabolic syndrome, and increased cardiovascular risk.<sup>21</sup> The prevalence of infertility in women with PCOS is 70%–80%,<sup>22</sup> with PCOS causing 75% of cases of anovulatory infertility.<sup>23</sup> IR is thought to play a role in PCOS-related infertility, perhaps through its impact on hyperandrogenism, contributing to anovulation.<sup>24</sup> Furthermore, both obesity and PCOS independently influence smaller oocyte size, thereby affecting maturation promotion activity.<sup>25</sup>

In a secondary analysis of two randomised controlled trials (RCT) studying women living with overweight/ obesity (age 18-40 years) with PCOS and infertility, a benefit of improved ovulation and live birth rate was seen when lifestyle modification with weight loss preceded infertility treatment with clomiphene citrate compared with medical management alone. Weight loss interventions included caloric restriction, anti-obesity medication, behavioural modification, and exercise during a 16week preconception intervention, after which clomiphene citrate was administered. The cumulative ovulation rate increased from 45% to 62%, and the live birth rate improved from 8.5% to 25% with lifestyle intervention.<sup>26</sup> Traditional weight-loss strategies at preconception were based on a low-fat, calorie-deficit diet<sup>27</sup>; however, a recent meta-analysis conducted on data from eight randomised controlled trials (n = 327) suggested that calorie deficit from a low-fat and low-CHO diet (fat <35% and CHO <45%) had a more significant effect on the levels of follicle-stimulating hormone (FSH) (MD = 0.40, 95% CI (0.09, 0.71)) and sex hormone-binding globulin (SHBG) (MD = 6.20, 95% CI (3.68, 8.72)) than a high-fat and low-CHO diet (fat >35% and CHO <45%).<sup>28</sup> Further research is required to evaluate the optimal amount of carbohydrate and duration of low carbohydrate intake.<sup>27</sup>

#### Diabetes

Increasing maternal age combined with a higher prevalence of obesity means an increased chance that women trying to conceive will be affected by metabolic disorders, such as type 2 diabetes. IR and obesity are risk factors for both PCOS and type 2 diabetes. Achieving a 5%–7% weight loss before planning conception aids in improving metabolic control.<sup>29</sup> HbA1C concentration correlates positively with the presence of menstrual irregularities and hypothalamic anovulation, and better glycaemic control is associated with a more regular menstrual cycle<sup>30</sup> and improved reproductive function.<sup>31</sup> A systematic review conducted by Franz et al. (2017), including 60 studies, evaluated the effectiveness of dietetic input in the management of diabetes. The findings suggested a reduction in HbA1C,

ranging from 0.3% to 1.8%, with ongoing dietetic care at 12 months.<sup>32</sup> Undernutrition in type 1 diabetes is also associated with female infertility.<sup>29</sup>

#### Coeliac Disease

Coeliac disease (CD) in women can lead to delayed puberty, infertility, amenorrhea, and precocious menopause.<sup>33</sup> CD-related malabsorption can lead to a deficiency of critical childbearing nutrients such as folate, iron, and vitamin K.<sup>34</sup> Though the prevalence of infertility is similar among those with CD and the general population, there is a higher maternal age among those with CD, as shown by the relative fertility rate.<sup>35</sup> The risk of miscarriage in infertile women with CD can be reduced nine-fold by strict adherence to a gluten-free diet.<sup>36</sup> It is advisable to screen women presenting with unexplained infertility or recurrent miscarriages for subclinical CD using serological tests.<sup>37</sup>

#### Anaemia

Epidemiological and animal studies suggest that iron deficiency anaemia may be linked to infertility, and case study reports have suggested a link between pernicious anaemia and infertility.<sup>38–40</sup> The mechanisms through which iron deficiency anaemia impacts fertility are not clear; however, it has been shown that iron-containing proteins are essential for ovum development and follicle maturation<sup>41</sup> and that in pigs, iron is involved in hormone secretion and cell proliferation.<sup>42</sup> Supplementation with nonheme iron may decrease the risk of ovulatory infertility,<sup>43</sup> and iron-rich water has been successful as prophylaxis for pregnant women to prevent iron deficiency anaemia; it is gentler on the gut compared to oral iron supplementation.<sup>44</sup>

Although pernicious anaemia is rare, once identified and treated with vitamin B12, women experiencing unexplained infertility can become pregnant within months.<sup>45</sup> Those at risk of vitamin B12 deficiency include individuals with malabsorption or restrictive dietary patterns, such as vegans. Ensuring nutritional adequacy of iron, folic acid, vitamin B12, protein, and vitamin C is essential for preventing and treating all types of anaemia.

#### Endometriosis

Endometriosis (a condition whereby endometrial tissue grows outside the uterus, in the surrounding organs and structures) affects about 10% of women of childbearing age<sup>46</sup> and is a chronic inflammatory, oxidative stress, oestrogendependent condition associated with infertility.<sup>47</sup> It accounts for up to 50% of infertility in women<sup>46</sup>; it is estimated that 30%–50% of women with endometriosis are infertile.<sup>48</sup>

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Endometriosis presents with symptoms including chronic pelvic pain, painful menstruation and ovulation, painful defecation, and persistent or recurrent genital pain occurring before, during, or after intercourse. Many of these features are similar to irritable bowel syndrome (IBS) and pelvic inflammatory disease (PID), and the probability of comorbidity between endometriosis and these two conditions is high.<sup>49</sup> Interventions with a low FODMAP diet conducted in a subgroup with IBS showed improvement in symptoms related to visceral hypersensitivity in 72% of women who presented with both endometriosis and IBS, whereas only 49% women had improvement who presented with IBS alone.<sup>50</sup>

Observational studies have shown that the following are associated with a reduced risk of endometriosis: limiting red meat,<sup>51</sup> endocrine disruptors, and increased vitamin D intake.<sup>52,53</sup> Qualitative interviews suggest potential benefits of dietary changes reducing endometriosis symptoms such as pain and menstrual cyclicity and increasing well-being. These changes include excluding or decreasing intake of certain foods, particularly gluten, dairy, and carbohydrates, and increasing intake of fruit, vegetables, and fish<sup>54</sup>; however, further research is needed in this area.

#### Fibroids

Uterine leiomyomata, commonly known as fibroids, are estimated to be present in 4.5%-68.6% of women under 50 years, 30% of which are asymptomatic.<sup>55</sup> The symptoms of fibroids include heavy bleeding, anaemia, extreme tiredness, painful periods, and infertility. Fibroids are present in 5%-10% of infertile women and may be the sole cause of infertility in 1%-2.4%.<sup>56</sup> Their impact on fertility depends on their location and if they are large enough to distort the endometrial cavity.<sup>5</sup> Vitamin D deficiency is believed to be related to uterine fibroids<sup>58</sup>; and optimal vitamin D status may restrict their growth.<sup>59</sup> Baird et al. found that for every 25 nmol/ L increase in serum 25(OH)D, there was a 20% reduction in the risk of having fibroids. They also found that if a woman's serum 25(OH)D level was >50 nmol/L, there was a 36% less risk of having fibroids, and the effect was independent of ethnicity.<sup>60</sup> An RCT supplementing 1250 ug/week vitamin D3 over 12 weeks in women with vitamin D deficiency resulted in halting fibroids' progression compared to the control group, where a significant increase in progression was seen.<sup>61</sup>

#### Thyroid Disorders

Medical management of thyroid disorders is essential for those with infertility as studies suggest that pregnancy outcomes are improved when TSH levels are kept <2.5mIU/L, which is stricter than the clinical guideline recommendation of <4.12 mIU/L for those with hypothyroidism alone.  $^{62-65}$ 

Despite a growing interest in the impact of nutrition on thyroid disorders, there is a lack of studies specifically exploring the impact of dietetic intervention for thyroid conditions among women with infertility, outside of weight management. However, it should be noted that lower vitamin D levels have been associated with hypothyroidism, autoimmune thyroid diseases and Hashimoto's thyroiditis, and iodine deficiency and iodine excess can both have negative implications for thyroid function.<sup>66,67</sup>

#### Nutritional Factors

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#### Energy Availability

Intentionally or unintentionally undereating (not consuming enough calories, food, or nutrients to meet the body's requirements) is linked to functional hypothalamic amenorrhea (FHA).<sup>11</sup> It is well established that starvation is associated with amenorrhea. Hypocaloric intakes and reduced energy availability (EA) can be linked to 'dieting', which itself may be associated with restriction of specific foods, food groups, or nutrients leading to negative impacts on fertility.<sup>68</sup> Dieting may also be associated with EDs, which are associated with high-risk pregnancies, several adverse perinatal outcomes,<sup>69,70</sup> and an elevated prevalence of iron deficiency anaemia and coffee/ caffeine consumption (both nutritional risk factors in infertility).<sup>71</sup> Even short-term undereating can negatively affect menstrual cycles prior to weight loss occurring, and modest reductions in energy availability over prolonged periods have been associated with menstrual disturbances and decreased LH pulse frequency.<sup>72,73</sup> Avoidance of foods or food groups can lead to nutritional inadequacies with negative effects on fertility. The importance of nutritional adequacy for fertility is discussed below.

#### Macronutrient Intakes and Fertility

#### Carbohydrate

There is evidence suggesting that consuming a diet with a low glycaemic load (GL), high in fibre and with plenty of whole grains, may have beneficial effects on fecundity and oestrogen levels.<sup>74–77</sup> In those with PCOS, a reduction in carbohydrate intake led to improved insulin sensitivity and reduced testosterone; however, these effects were not seen in healthy menstruating women.<sup>78–80</sup> Some studies suggest that sugar-sweetened beverages (SSB) are detrimental to fertility, with intakes

of SSBs being associated with reduced fecundability and reduced reproductive success in those undergoing IVF.<sup>81,82</sup>

#### Protein

In a study by Chavarro and colleagues, 18,555 women with a history of infertility were followed as they attempted a pregnancy during an 8-year period. It was found that consuming vegetable protein instead of carbohydrates or animal protein was associated with a substantially lower risk of ovulatory infertility.<sup>83</sup> In a study considering 2696 embryos from 269 patients undergoing intracytoplasmic sperm injection cycles, red meat had a negative effect on blastocyst formation. implantation rates, and the probability of a live birth,<sup>84</sup> whereas a study of 351 women showed that fish intake was associated with a higher probability of live birth following assisted reproductive technology (ART), especially when fish replaced processed meat.<sup>85</sup> A differential effect of varying proteins on insulin sensitivity may explain these findings, in addition to the replacement of carbohydrate sources with vegetable protein, likely reducing the glycemic index (GI) of a meal.<sup>86</sup>

#### Fat

Fatty acids (FA) are known to play an important role in reproductive function, with evidence suggesting that increased omega-3 polyunsaturated fatty acid (PUFA) intakes, reduced trans FAs and saturated FA intakes may enhance fertility.<sup>5,87–89</sup> Increased PUFA intakes have been associated with higher fecundity, shorter timeto-pregnancy, and better ART outcomes; however, no dose-response relationship has been established.<sup>89–91</sup> Trans-FAs are known to increase insulin resistance and, in the NHS-II study, were associated with higher risks of ovulatory infertility.<sup>5</sup> Minimal work has been done looking specifically at the effects of saturated fat on fertility, though a recent study showed that higher intakes of saturated fat were associated with an adjusted relative risk of 0.67 for clinical pregnancy in women undergoing ART.<sup>92</sup> The effects of other FAs on fertility, including omega-6 polyunsaturated FAs and monounsaturated FAs, are not yet clear.<sup>90,93</sup>

#### Foods and Food Groups

#### Seafood Consumption

There is growing evidence showing an association between fish intake and improved fertility. Nassan et al. showed that replacing meat with fish improves the probability of live births following ART.<sup>85,88,89</sup> Hsi

and colleagues assessed the MeHg concentration in the hair of infertile women versus pregnant women (n = 224), with the infertile cohort showing significantly greater levels.<sup>94</sup> The potential negative effects of environmental toxins from seafood consumption are not clear, but overall, there are clear benefits to oily fish consumption with low mercury levels. Although the link between mercury and fertility is inconclusive, fish containing lower levels of mercury are recommended for women who wish to conceive.<sup>95,96</sup>

#### Soy

Although controversy exists around soy intake and reproduction, with more research needed,<sup>97,98</sup> observational evidence suggests that higher intakes of soy isoflavones have been associated with 77% higher fertilisation rate in those undergoing ART compared to not consuming soy.<sup>99</sup> Interventional studies show positive effects of soy supplementation in those undergoing ART with Unfer et al. showing lower rates of miscarriage and higher rates of pregnancy with 1500 mg/day phytoestrogen supplementation in those undergoing IUI, compared to placebo<sup>100,101</sup> and a study by Shahin and colleagues finding that 120 mg/day oral phytoestrogen in those with unexplained infertility undergoing ovulation induction was associated with shorter induction cycles, and higher endometrial thickness and pregnancy rates.<sup>100,101</sup> Although the mechanisms for these positive effects are not clear, it is suggested that phytoestrogens may have oestrogenic effects or act as oestrogenic agonists in addition to being potent antioxidants.

#### Dairy

The fertility risk factor study by Greenlee and colleagues examined agricultural and residential exposures associated with female infertility; the study of 322 women found that consuming three or more glasses of milk per day is protective of female fertility, with consumers having a 70% lower risk of infertility than nonconsumers.<sup>102</sup> Chavarro et al. (2007) followed 18,555 married, premenopausal women without a history of infertility who attempted pregnancy or got pregnant within an 8-year period and found that high-fat dairy intake compared to low-fat dairy intake has been associated with a lower risk of ovulatory infertility.<sup>103,104</sup> Conversely, results from a study that considered foodfrequency questionnaire data from two cohort studies in Denmark and North America did not support the hypothesis that full-fat dairy was superior to low-fat dairy in promoting fertility,<sup>105</sup> so no strong conclusions can currently be made regarding the type of dairy intake.

#### Alcohol

Fan et al. (2017) showed that alcohol intake was associated with reduced fecundability, with risk increasing in a dose-response manner.<sup>106</sup> Heavy alcohol use is thought to diminish the ovarian reserve and is associated

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with multiple reproductive risks, including decreased chance of having a live birth and increased risk of foetal loss and having a child with foetal alcohol syndrome.<sup>107</sup> There is substantial evidence that alcohol intake, even moderate consumption, can negatively affect ART outcomes.<sup>108,109</sup> The expert opinion from the Maternal and Fertility Nutrition Specialist Group from British Dietetic Association (BDA) and Royal College of Obstetricians and Gynaecologists (RCOG) suggests it is safest to avoid alcohol intake prior to treatment.

#### Caffeine

Bolumar et al.<sup>110</sup> suggested that a high intake of caffeine (>500 mg per day) increased time-to-pregnancy, but there is inconsistent evidence regarding the effect of moderate caffeine intake on fertility outcomes.<sup>110,111</sup> Beyond fertility, the link between caffeine and pregnancy outcomes is clearer, with increased caffeine consumption linked to spontaneous abortion.<sup>112</sup> Evidence regarding outcomes and IVF caffeine intake remains inconsistent.<sup>113,114</sup> As cited by the European Food Safety Authority, the Belgian Superior Health Authority (2012) recommends that women of childbearing age consume <200 mg caffeine per day.<sup>115,116</sup> This precautionary advice is supported by others,<sup>117</sup> with some authors suggesting this intake may still be too high.<sup>112</sup>

#### Micronutrients

#### Vitamin D

Recommended intake (RNI) of vitamin D for UK adults is 10ug/day unless deficiency is present.<sup>118</sup> There is no specific recommendation for those trying to conceive or experiencing infertility; however, vitamin D deficiency and insufficiency (serum level <75 nmol/L) is linked to lower success rates for women undergoing fertility treatments.<sup>119</sup> Research suggests that vitamin D may be beneficial for women with PCOS, insulin resistance, or low levels of anti-Mullerian hormone (AMH), and a deficiency of vitamin D is associated with the pathogenesis of endometriosis.<sup>120,121</sup> The authors propose that the improved fertility rates may be due to the immunomodulatory effect of vitamin D via the reduction of inflammatory cytokines<sup>122</sup> and a direct impact on the endometrium.<sup>123</sup>

Vitamin D may be beneficial only for women with disorders like PCOS, insulin resistance, or low levels of AMH.

#### Folate and Folic Acid

Folate is the natural form of vitamin B9 found in foods, and folic acid is the synthetic version found in supplements and fortified foods. Both forms can prevent folate deficiency, which currently occurs in 20%–40% of women of reproductive age.<sup>124</sup> Current UK recommendations advise women planning to conceive to take 400ug/day

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Zinc

folic acid from 3 months prior to conception and during pregnancy and consume a folate-rich diet to prevent neural tube defects (NTD). For those at higher risk of NTDs (those with previous pregnancy of NTD, male partner with a history of NTD, periconceptional anti-epileptic drug exposure, pre-existing diabetes, and pre-pregnancy obesity<sup>125</sup>), a higher dose of 5 mg/day is recommended.<sup>125,126</sup> However, these women should also be assessed for vitamin B12 deficiency as high dose of folic acid supplementation may mask vitamin B12 deficiency.<sup>127</sup> Where deficiency is found, a vitamin B12 supplement of 2.6ug/day should be recommended.<sup>125</sup>

Supplemental intake of folic acid has been shown not only to prevent NTDs<sup>125</sup> but also to reduce the risk of infertility and improve outcomes of infertility treatment. Fertility outcomes appear to favour supplemental folate over dietary folate,<sup>128</sup> with higher synthetic folate intake associated with higher luteal progesterone and decreased odds of anovulation and so may improve chances of conception further.<sup>88</sup>

#### Vitamin B12

Although rare, vitamin B12 deficiency is associated with infertility, abnormal egg development, and miscarriage.<sup>38</sup> In those undergoing ART, a higher serum B12 concentration is associated with higher live birth rates.<sup>129</sup> Current UK consensus on recommended intake of vitamin B12 is  $1.5 \,\mu$ g/day for those trying to conceive (2.6  $\mu$ g if taking a high dose of folic acid); however, given the high prevalence of deficiency in women of childbearing age, it has been suggested that the RNI be increased to around 5–7 $\mu$ g/day, or at least to the European recommendations of 4.5 $\mu$ g/day.<sup>130</sup> As previously mentioned, this is of particular importance in those trying to conceive who are at higher risk of B12 deficiency.

#### Iron

Iron deficiency is associated with ovulatory infertility and reduced conception rates,<sup>40,43</sup> and in pregnancy, with low birth weight and developmental delay.<sup>131</sup> Ideally, iron status should be optimised prior to conception as supplemental iron can cause GI distress and interfere with nutrient absorption. RNI of iron in women of childbearing age is 14.8  $\mu$ g/day, higher in those with measured deficiency.

#### Iodine

Moderate to severe iodine deficiency is associated with a 46% decrease in fecundability,<sup>132</sup> and in pregnancy, it is associated with adverse effects on foetal growth and cognitive development, and an increase in preeclampsia and preterm delivery.<sup>133–135</sup> Studies suggest that initiating iodine supplement use in pregnancy may be too late and that supplementation with 150  $\mu$ g/day should begin preconception.

# Zinc plays a key role in many processes involved in female fertility and pregnancy, including ovulation and oocyte maturation.<sup>136,137</sup> However, there is a lack of supplementation studies in women, preventing any specific recommendations.<sup>138</sup>

#### Vitamin A

Fertility nutrition is not limited to successful conception but aims towards a live pregnancy and healthy offspring. Vitamin A is associated with a teratogenic impact when supplemented in high doses such as 15,000 IU (4500 ug retinol equivalents [RE]) from diet or more than 10,000 IU (3000 RE) from supplements.<sup>139,140</sup> These levels of intake are not rare in high-income countries, especially with habitual multivitamin supplementation and/or intake of organ meats (e.g., liver). Increased circulating retinoic acid in the first trimester can lead to miscarriage and congenital malformations.<sup>141</sup> The UK NICE guidelines advise avoiding supplementation of more than 5000 IU vitamin A (1500 ug).<sup>142</sup> Prenatal supplementations containing beta carotene are not associated with negative outcomes.<sup>141</sup> Women still need to meet their recommended daily allowance from food sources. Animal studies suggest the importance of vitamin A during the implantation stages<sup>143</sup>; human trials are needed to evaluate the relevance.

#### **Dietary Patterns**

Despite growing evidence to suggest that plant-based diets have beneficial health effects and the suggestion that vegetable protein is superior to animal protein for fertility,<sup>85</sup> there are also data to suggest that vegetarians are more likely to have menstrual irregularities than non-vegetarians, 26.5% vs 4.9%, respectively.<sup>144</sup> High fibre, low fat, and no meat consumption seen in vegetarians have been associated with lower oestrogen levels.<sup>144</sup> However, more recent research suggests that in long-term, weight-stable vegetarians with a healthy BMI, vegetarianism per se is not associated with increased menstrual cycle disturbances,<sup>145</sup> suggesting that a well-planned nutritionally adequate vegetarian diet may not be detrimental to fertility. Particular importance should be paid to vitamin B12, selenium, iodine, iron, choline, and omega-3 PUFA which may be deficient in a plant-based diet.

Regarding dietary patterns and protective effects on fertility and conception, a Mediterranean diet of whole grains, unsaturated fats, vegetables, and fish is shown to be effective.<sup>88,146</sup> Furthermore, the Mediterranean diet has been shown to improve outcomes in women undergoing IVF treatment.<sup>147–149</sup> A lower risk of difficulty conceiving was seen in subjects with high adherence to the Mediterranean diet compared to those with the least adherence.<sup>150</sup>

A 2007 study by Chavarro et al. showed a 'fertility diet' (consisting of high consumption of MUFA with reduced trans-fat consumption, high vegetable protein and less animal protein intake, high-fat dairy, low glycaemic carbohydrates and high whole grain and fibre intake, multivitamin intake as well as more vegetarian sources of iron) was associated with 66% lower risk of ovulatory fertility and 27% reduced risk of infertility from other causes.<sup>5</sup>

 TABLE 1
 Summary of nutritional factors affecting fertility

### Summary of Nutritional Factors

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As summarised in Table 1, female fertility is negatively affected by reduced energy availability, high glycaemic load, and high carbohydrate intake, high trans-fat intake, and high animal protein intake. Positive effects

Nutritional factor	Suggested intake for fertility	Reported impact on fertility	References
Energy availability	Ensure adequate energy intake	Ensure energy provision for reproductive function	11, 68, 72, 72,
Carbohydrate	Low glycemic index preferable, reduce high GI, include whole grains, high fibre	Beneficial effects on fecundity and oestrogen levels	74-77
Protein	Plant based > animal based. Include fish	Replacing animal sources of protein with plant- based sources of protein may reduce ovulatory infertility risk.	83, 84, 85, 86
Fat	MUFA/PUFA > SFA and trans fat	Leads to higher fecundity, shorter time-to- pregnancy, and better ART outcomes	5, 87-92
Foods and food grou	ps		
Seafood	1–2 portions fish per week 1 oily fish (max 2 due to heavy metals)	Fish consumption linked to shorter time to pregnancy and increased probability of live births following ART	85, 88, 89
Soy	Soy intake from foods may be beneficial to those with infertility, though evidence is not conclusive.	Linked to higher ART success	99, 100, 101,
Dairy	2-3 servings of dairy/day	Dairy is protective of fertility.	102, 103, 104, 105
Whole grains	Include whole grains as per healthy eating guidelines.	Linked to beneficial effects on fecundity and oestrogen levels	74-77
Red meat	As per healthy eating guidelines, replace some animal protein with plant protein.	Linked to infertility and associated with reduced ART success	84, 85
Alcohol	Avoid	Linked to reduced fecundability with risk increasing in a dose-response manner, and to reduced ART success	106, 107, 108, 109
Caffeine	Limit to <200 µg/day	Increased time-to-pregnancy	110, 111
Micronutrients			
Vitamin D	10 μg/day. Test to identify any deficiency and supplement further as necessary.	Improves reproductive health; deficiency and insufficiency linked to lower ART success rates	118, 119
Folate/folic acid	$400 \mu g$ per day, 5 mg if special conditions	Reduces risk of neural tube defects and promotes egg quality	125, 126
Vitamin B12	$1.5\mu g$ (2.6 $\mu g$ if taking high dose of folic acid)	Important for implantation and maintaining a healthy pregnancy	38, 125, 127
Iron	14.8 mg or address deficiency	Essential for healthy and regular ovulation. Deficiency linked to ovulatory infertility and reduced conception rates.	40, 43
Iodine	150 µg	Ensures healthy menstruation and improves chances of pregnancy; important for healthy development of baby	132, 133-135
Zinc	Insufficient evidence to make a recommendation	Important for healthy ovulation and menstruation, as well as early development of embryo	136, 137, 138
Vitamin A	Avoid supplementation of >1500 µg vitamin A. Beta carotene is preferred source for supplementation.	Teratogenic effects in high doses	139, 140, 141, 142

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TA	BLE	2 Proposed ferti	lity nutrition screening tool				
Se	ection a	and question			Score	e	
A.	Body	mass index (BMI)					
B	MI can	be calculated using	g weight (kg)/height (m) <sup>2</sup> . You could	ask your nurse to help you out with it.			
					Yes	No	Yes = 1, No = 0
1)	Is you	ur BMI between 25	5 and 30 kg/m <sup>2</sup> ?				
					Yes	No	Yes = 2, No = 0
2)	Is you	ur BMI less than 19	$9 \text{ kg/m}^2$ or higher than $30 \text{ kg/m}^{2?}$				
B.	Medie	cal history					
D	o you h	nave <i>any</i> of the follow	ving conditions which could influence	your nutrition status?	Yes	No	Yes = 2, No = 0
3)	If you	ır haemoglobin is t	ested and is <110 g/L or you have b	een diagnosed with anaemia			
4)	Newly	y diagnosed/poorly	managed coeliac disease				
5)	Polyc	ystic ovary disease					
6)	Unco	ntrolled diabetes					
7)	Diagn consti	nosed with endome	triosis/fibroids and have symptoms s	uch as abdominal pain/bloating/diarrhoea/			
8)	Histor	ry of excessive diet	ing in the past 3–6 months or had a	history of eating disorders			
9)	Any r status	medical condition c	ausing poor appetite/swallowing diff	culty/malabsorption leading to poor nutritional			
C.	Quali	ity of diet and lifest	yle checklist:				
Н	ave yo	u been following ea	ach of the following preconception p	ractices in the past 3–6 months?			
N	utrition	ı adequacy			Yes	No	Yes = 0, No = 1
10)	Do y	you abstain from a	lcohol consumption?				
11)	Do y prod	you restrict any ma lucts, animal produ	jor food group such as whole grains acts, fruits, or vegetables for health/r	(or other carbohydrate sources), milk and dairy eligious/personal reasons?			
12)	Do y	you regularly eat m	nore than 4–5 portions of fruit and v	egetables per day?			
13)	Do y	you include vegetar	rian/animal protein at least 2-3 times	per day?			
14)	Do y	you consume oily fi	ish 1–2 times per week?				
15)	Do y milk	you at least consum every day?	ne 2-3 portions of dairy products (su	ch as milk/cheese/yoghurt)/fortified plant-based			
16)	Do y	you eat whole grair	n carbohydrate food (such as brown	bread, brown pasta, brown rice) every day?			
17)	Do y preco nutri	you regularly use ap onception-specific r ients for preconcep	propriate supplementation of 400 mc nultivitamins (containing folic acid a tion)	g folic acid + 10 mcg vitamin D (winter months)/ Ind vitamin D provision along with other			
18)	Do y	you take any other	vitamins/minerals to improve fertilit	y (apart from the ones mentioned in Q17)?			
Li	ifestyle	factors			Yes	No	Yes = 0, No = 1
19)	Do y	you get at least 150	min of moderate physical activity e	ach week?			
20)	Do y preg	you think you have nancy? On a scale	e a good understanding about health of 0–10, where 10 is very confident,	y eating and nutrition for preconception and if you think you score above 7 then mark yes.			
Т	otal sco	ore (maximum score	e = <b>28</b> )				

are seen with intakes of omega-3 PUFAs, especially oily fish intake, low GI load, high intake of whole grains, reduced carbohydrate intake, vegetable protein intake, and high antioxidant intakes. Soy intake may be beneficial to those struggling with infertility. Many micronutrient deficiencies have been associated with infertility, and optimising intakes and status of micronutrients such as vitamin D, folate, vitamin B12, iron, iodine, and zinc may offer improvements in fertility, though further research is required to make specific recommendations regarding multivitamin/mineral supplementation. An overall dietary pattern in accordance with the Mediterranean diet style of eating has the most evidence in support of improved fertility. Further research is needed to decipher the effects of full-fat dairy intake on fertility, though there are some promising data.

#### Nutritional Inadequacy

In addition to the medical conditions already mentioned, other health conditions are often linked to nutritional inadequacies, including swallowing difficulties, food allergies/intolerances, restrictive diets, malabsorption conditions, post-bariatric surgery, and post active oncology treatments, all of which could benefit from dietetic assessment and intervention, ensuring nutritional adequacy for the first 1000 days of life. Therefore the proposed self-screening tool needs to accompany clinical judgement.

#### Lifestyle Factors

#### Physical Activity

Evidence suggests that although moderate, regular physical activity (PA) can positively influence fertility and ART outcomes, high-intensity PA has been associated with poorer fertility outcomes.<sup>151</sup> Inactivity and sedentary behaviours are also associated with higher rates of infertility.<sup>152</sup> Decreasing PA can be particularly effective in women with functional hypothalamic amenorrhea to improve energy balance and reverse amenorrhea.<sup>12</sup>

#### Stress

There is a well-known association between infertility and stress, with infertile individuals reporting higher levels of depression and anxiety than fertile individuals<sup>153</sup>; however, it has been less clear if stress causes infertility. Recent reviews suggest that psychological interventions can be effective in reducing anxiety and depression, which could improve pregnancy rates in infertile women,<sup>154</sup> supporting a holistic approach to fertility management.

#### Smoking

Strong evidence exists to suggest that smoking has an adverse effect on reproductive capabilities and promotes infertility in men and women.<sup>155,156</sup> Smoking can also

have adverse effects on ARTs, affecting ovarian reserves and decreasing fertilisation rates.<sup>157</sup>

#### PROPOSED FERTILITY NUTRITION SCREENING TOOL

To identify those in need of nutritional support in their fertility journey, a simple, self-administered nutrition screening tool is proposed in Table 2.

A score of 1 or above demonstrates nutrition risk that the dietitian could organise self-help resources such as a group education, webinar, or factsheet. A score of 2 and above requires a dietetic referral to be made. Further research is required to validate the tool.

#### CONCLUSION

Given the lack of gold standard for comparison, validating this tool is currently difficult. As a selfadministered tool, it requires further review with clinical judgement on the type and extent of dietetic involvement. The scope of this tool is limited to identify gaps in nutrition status and a potential link to subclinical and clinical infertility. It could also help identify women who would benefit from a higher folic acid supplementation, identify the need for monitoring serum levels of specific nutrients, and prioritise where a fertility dietitian can provide nutrition intervention with educational material, group or one-on-one consultations. Further research is mandated to adapt the screening tool in different settings and to assess the impact of the tool in identifying nutritional needs in those with infertility, perhaps through comparison to dietetic nutrition assessments as previously done with tools such as SGA.

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#### PRINCIPLES OF NUTRITION AND DIETETICS

## Evidence of low vitamin D intakes in the Australian population points to a need for data-driven nutrition policy for improving population vitamin D status

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#### Abstract

**Background:** Nearly one in four Australian adults is vitamin D deficient (serum 25-hydroxyvitamin D concentrations  $[25(OH)D] < 50 \text{ nmol } L^{-1}$ ) and current vitamin D intakes in the Australian population are unknown. Internationally, vitamin D intakes are commonly below recommendations, although estimates generally rely on food composition data that do not include 25(OH)D. We aimed to estimate usual vitamin D intakes in the Australian population.

*HND* 

**Methods:** Nationally representative food consumption data were collected for Australians aged  $\geq 2$  years (n = 12,153) as part of the cross-sectional 2011–2013 Australian Health Survey (AHS). New analytical vitamin D food composition data for vitamin D<sub>3</sub>, 25(OH)D<sub>3</sub>, vitamin D<sub>2</sub> and 25(OH)D<sub>2</sub> were mapped to foods and beverages that were commonly consumed by AHS participants. Usual vitamin D intakes ( $\mu g \, day^{-1}$ ) by sex and age group were estimated using the National Cancer Institute method.

**Results:** Assuming a 25(OH)D bioactivity factor of 1, mean daily intakes of vitamin D ranged between 1.84 and  $3.25 \,\mu g \, day^{-1}$ . Compared to the estimated average requirement of 10  $\mu g \, day^{-1}$  recommended by the Institute of Medicine, more than 95% of people had inadequate vitamin D intakes. We estimated that no participant exceeded the Institute of Medicine's Upper Level of Intake (63–100  $\mu g \, day^{-1}$ , depending on age group).

**Conclusions:** Usual vitamin D intakes in Australia are low. This evidence, paired with the high prevalence of vitamin D deficiency in Australia, suggests that data-driven nutrition policy is required to safely increase dietary intakes of vitamin D and improve vitamin D status at the population level.

#### **KEYWORDS**

25-hydroxyvitamin D, Australia, food, usual intakes, vitamin D

#### Key points

• We quantified usual intakes of vitamin D in the Australian population using up-to-date, comprehensive vitamin D composition data and nationally representative food consumption data.

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- Mean usual intakes ranged between 1.8 and  $3.2\,\mu g$  day<sup>-1</sup>, assuming equal bioactivity of the D vitamers.
- We estimated that more than 95% of the population had inadequate vitamin D intakes compared to the estimated average requirement  $(10 \,\mu g \, da y^{-1})$  recommended by the Institute of Medicine.
- This new evidence of low vitamin D intakes, together with high prevalence of vitamin D deficiency in Australia, suggests that data driven nutrition policy is required to safely increase intakes of vitamin D and improve vitamin D status at the population level.

#### INTRODUCTION

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Vitamin D deficiency (serum 25-hydroxyvitamin D [25(OH)D] concentrations < 50 nmol  $L^{-1}$ )<sup>1</sup> affects many Australians (20% of adults aged  $\geq$  25 years,<sup>2</sup> 32% of young adults aged 18-24 years and 17% adolescents aged 12–17 years<sup>3</sup>). To date, there has not been an assessment of usual vitamin D dietary intakes in the Australian population using comprehensive vitamin D food composition data and nationally representative food consumption data. Elsewhere, vitamin D intakes fall short of recommendations. In the USA,<sup>4</sup> Canada<sup>5</sup> and many European countries,<sup>6-8</sup> estimated mean intakes of vitamin D are  $\leq 5 \,\mu g \, day^{-1}$ , which is considerably lower than the estimated average requirement (EAR) of  $10 \,\mu g \, day^{-1}$ recommended by the Institute of Medicine.<sup>9</sup> Those estimates, however, do not appear to have accounted for the contribution of all D vitamers that may be present in food,<sup>10-20</sup> particularly 25(OH)D that is present in some foods, and may be more biologically active than vitamin D itself.<sup>21</sup>

Previous estimates of Australian vitamin D intakes were low  $(2-3 \mu g \text{ day}^{-1})$ ,<sup>22,23</sup> but were based on very limited vitamin D food composition data and/or used data produced using outdated analytical methods. The high prevalence of vitamin D deficiency reported recently<sup>1-3</sup> suggests that intakes are too low to compensate for inadequate safe sun exposure. This is because naturally rich food sources of vitamin D are uncommon and few food products are fortified with vitamin D in Australia. Fortification has been suggested as a potential solution to low vitamin D status.<sup>6,7,24,25</sup> In the Finnish population, vitamin D intakes from food alone were approximately doubled following addition of vitamin D to fluid milk products and fat spreads, and the prevalence of people with serum 25(OH)D concentrations  $<50 \text{ nmol } \text{L}^{-1}$  decreased from 56% in 2000 to 9% in 2011.<sup>26</sup> However, dietary strategies to improve vitamin D status in the Australian population cannot be modelled without an accurate estimate of usual baseline intakes.

The 2011–2012 National Nutrition and Physical Activity Survey (NNPAS)<sup>27</sup> provides the most comprehensive and nationally-representative food and dietary supplement consumption data in Australia to date. These food consumption data and the serum 25(OH)D

concentrations used to estimate the prevalence of vitamin D deficiency were collected during the same period; therefore, it is relevant to consider them together. However, vitamin D intakes were not estimated as a result of a lack of locally-relevant vitamin D food composition data.<sup>28</sup> Recently, Australia's first comprehensive analytical vitamin D food composition database was produced<sup>29</sup> using liquid chromatography with triple quadrupole mass spectrometry, a highly sensitive and specific method for measurement of D vitamers. Hence, we aimed to provide the first estimates of usual vitamin D intakes in a nationally representative sample of the Australian population, and to identify the major food sources of vitamin D, based on new comprehensive vitamin D food composition data.

#### METHODS

We used nationally representative food (including beverages) and dietary supplement consumption data and new analytical vitamin D food composition data to estimate vitamin D intakes in the Australian population using either the National Cancer Institute (NCI) method (for usual intakes of food) (Figure 1) or a determinisitic method (including dietary supplements).

#### Study population

The Australian Health Survey (AHS) 2011–2013 provided the most recent nationally representative healthrelated data for the Australian population.<sup>27</sup> Usual residents of metropolitan and rural private dwellings were eligible. An area-based sampling approach was adopted to ensure geographically representative sampling. Approximately 35,000 households were selected with the aim of achieving approximately 26,000 fullyresponding households, allowing for non-response and sample attrition (see Supporting information, Figure S1). Core demographic, household and other general information (published previously)<sup>30</sup> were collected for one adult or one adult plus one child from 25,080 households. Participants were then allocated to either the National Health Survey (n = 20,426), which focused on FIGURE 1 Methods for estimating usual vitamin D intakes in the Australian population: 2011–2012 National Nutrition and Physical Activity Survey (NNPAS)



health status and conditions, or the NNPAS (n = 12,153), which included a food consumption component.

#### Food consumption data

Food and dietary supplement consumption data were collected for Australians aged  $\geq 2$  years by trained Australian Bureau of Statistics (ABS) interviewers. Food consumption collection methods have been described in detail by the ABS.<sup>29</sup> In summary, the United States Department of Agriculture Dietary Intake Data System<sup>31</sup> was used to collect and code food consumption data. This digital system comprises the Automated Multiple-Pass Method<sup>32</sup> for 24-h dietary recall, the Post Interview Processing System (PIPS)<sup>31</sup> and Survey Net<sup>31</sup>. The Automated Multiple-Pass Method was modified by the ABS in collaboration with Food Standards Australia New Zealand (FSANZ) to represent foods consumed in Australia. Participants were invited to complete two 24-h dietary recalls: the first was conducted during an inperson interview (n = 12, 153) and the second by telephone call (completed by 64% of participants, n = 7,735). Where possible, the second interview was scheduled at least 8 days after the first and on a different day of the week. These interviews were conducted under the Census and Statistics Act 1905. A responsible adult responded for all children aged < 15 years and also for children aged 15-17 years where permission for self-response was denied by a parent or guardian. All data were recorded electronically during interviews. As respondents identified foods and dietary supplements that were consumed, questions specific to the type of these were prompted by the adapted Automated Multiple-Pass Method program to determine details about the food and its preparation. The AHS Food Model Booklet<sup>33</sup> aided estimation of the amounts of foods consumed. Interview data were prepared and partially coded in PIPS. Final coding and

calculation of the gram weight of consumed items were carried out in Survey Net, which incorporated a food measures database compiled by FSANZ for the AHS.<sup>27</sup> The coded data were imported into Harvest, FSANZ's custom-built dietary modelling software.<sup>34</sup>

#### Vitamin D food composition data

Analytical vitamin D composition data were obtained as described previously.<sup>28</sup> In brief, a sampling plan was developed to include food products that were reported in the NNPAS as being commonly consumed (as per past nutrition surveys and knowledge of current market availability) or that were expected to contain vitamin D. Between August 2018 and June 2019, 896 primary food samples of 98 different food products were purchased in three cities representing both sides of the continent and where approximately half of Australia's population resides: Sydney (August 2018; 186 samples), Melbourne (October to December 2018; 516 samples) and Perth (April to June 2019; 194 samples). Products were purchased in one, two or three cities depending on the likelihood of high vitamin D concentration in the product, frequency of consumption and whether they are produced and used regionally or distributed nationally from one source. Primary samples were composited into 149 analytical samples each comprising six primary samples per food type per city, with the exception of dark chocolate, for which eight primary samples were combined. Vitamin D<sub>3</sub>, 25(OH)D<sub>3</sub>, vitamin D<sub>2</sub> and  $25(OH)D_2$  were analysed in duplicate using a liquid chromatography with triple quadrupole mass spectrometry method at the National Measurement Institute of Australia, a National Association of Testing Authoritiesaccredited laboratory for measurement of vitamin D in food. A detailed description of the analytical method has been published previously.<sup>28</sup>

# Calculating vitamin D equivalents from analytical food composition data

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Vitamin D equivalents (VDE) were calculated by summing concentrations of the four D vitamers measured, assuming equal bioactivity. Currently, there is no consensus on a bioactivity factor for 25(OH)D.<sup>21</sup> Where it is included in national food composition databases, a bioactivity factor of either '1' or '5' is used. Hence, we estimated intakes using both bioactivity factors to allow comparison with other studies. Trace values, where the concentration of a nutrient is detected below the limit of reporting (LOR) and cannot be quantitated with certainty, present a risk of under-estimation (if trace values are assigned a 0 value) or over-estimation (if trace values are assigned the LOR value) of nutrient intakes. Trace values were therefore assigned a value of LOR/2  $(LOR = 0.1 \mu g \text{ per } 100 \text{ g for all foods except those with a})$ high fat content, for which the LOR was 0.25 µg per 100 g).

#### Mapping analytical data to consumed foods

Australia's nutrition survey food composition database, AUSNUT,<sup>27</sup> is used to estimate usual nutrient intakes based on food consumption data from the NNPAS. Because vitamin D was not included in AUSNUT 2011–2013, we mapped our new analytical vitamin D data to AUSNUT food entries.

The process of mapping analytical concentrations to consumed foods was conducted using the same method as for Australian total diet studies.<sup>35,36</sup> Mapping can consist of direct mapping of concentrations to foods, direct mapping with factors applied or assigning a recipe. The 5,740 food entries in AUSNUT can be divided into two types: non-recipe foods (individual, staple-type foods, such as rice) and recipe foods (foods that contain more than one non-recipe food, such as fried rice). We manually assigned analytical D vitamer concentrations to all nonrecipe foods, with the exception of oral nutritional supplements and meal-replacement products designed for weight loss (n = 21), for which label data were used. Methods of data derivation were recorded together with details, such as label data source, where appropriate. The direct mapping with factors method allows the mapping of a food's analytical concentration to other relevant foods with an additional adjustment factor applied to account for food manufacturing or preparation practices such as dehydration or cooking in water.<sup>35</sup> For example, a conversion factor would be applied to the analytical value for powdered infant formula to derive a value for readyto-drink infant formula.<sup>35</sup> Similarly, a conversion factor would be applied to the analytical value for apple to derive a value for apple juice.<sup>35</sup>

Concentration values were derived for recipe foods using Harvest.<sup>34</sup> Harvest allows for multiple levels of

nested recipes, such as a recipe within a recipe within a recipe. For example, a recipe for 'filled pasta with cheese sauce' contains 'filled pasta' and 'cheese sauce' as separate ingredients. These ingredients are in turn made from recipes. Harvest determines a nutrient concentration for the mixed food based on the nutrient concentrations for ingredient foods and the proportion of an ingredient within a recipe.

# Estimating vitamin D concentrations for raw versions of analysed cooked foods

To sample as diverse a range of foods as possible with the available funds, we prioritised the analysis of foods in the form that they are consumed, such as cooked meats, fish and seafood rather than raw; however, some recipe foods include raw versions of these foods as ingredients and therefore values for the raw food were estimated. Conversion factors, as explained in the previous section, were applied to cooked meat and seafood concentrations to derive values for raw versions to use in these recipes: however, this did not include retention factors because retention factors were not listed for vitamin D in the AUSNUT 2011–2013 data files.<sup>27</sup> Retention factors for different foods and cooking methods were published in 2002<sup>37</sup>; however, there is limited up-to-date data on the retention of vitamin D in foods. A recent study examined retention factors for vitamin D in farmed Danish rainbow trout using eight different cooking methods and temperatures, finding that true retention of vitamin D ranged between  $85 \pm 6\%$  and  $114 \pm 13\%$ .<sup>38</sup> Hence, it is possible that the use of retention factors may introduce error rather than reduce it. In the present study, omitting retention factors should have no major effect on intake estimates because the vitamin D concentration values used were derived from levels of vitamin D in foods as consumed.

#### **Estimating intakes**

Usual intakes of vitamin D were estimated using the NCI Method.<sup>39</sup> Implementation of the method was consistent with the approach taken by the ABS and FSANZ in estimating usual nutrient intakes for the NNPAS. Further information about this approach is available elsewhere.<sup>29</sup>

To apply the NCI method, at least two dietary intakes for a subset of survey respondents are required. Using the NNPAS 24-h dietary recall data and our new vitamin D food composition data, vitamin D intakes for each respondent for either day 1 only, or for the two survey days (64% of respondents), were calculated using Harvest, which is the custom-built dietary modelling program used by FSANZ.<sup>34</sup> These Harvest-generated intake data were then used as the input for the NCI

method. Rather than using NCI macros for SAS software (SAS Institute Inc.), the NCI model was run in R, version 3.0.3 (R Foundation).<sup>40</sup> FSANZ previously translated the SAS macros into R code. At the time of translation, FSANZ undertook testing to validate the R code. Outputs from R were compared and found to be consistent with those from SAS software (Hambridge, T. L., unpublished data).

A summary of the specific NCI model set-up is as follows. The amount-only model type was used to estimate usual intakes because almost all respondents had a non-zero intake for vitamin D on day 1 of the NNPAS. The covariates used in the model were sex, age, weekend versus weekday and sequence effect (which considers the potential reporting differences between day 1 and day 2 of the nutrition survey). The default of 100 simulations for each respondent was used in the Monte Carlo simulation component of the model. The model was run separately for three population groups: children  $\leq 8$  years, males  $\geq 9$  years and females  $\geq 9$  years. This ensured that the model fitting was performed more specifically using respondents with similar food consumption patterns. Usual vitamin D intakes were then extracted and reported in  $\mu g \, day^{-1}$  by the age/sex groups used in the Nutrient Reference Values (NRVs) for Australia and New Zealand.<sup>41</sup>

#### Estimating adequacy of intakes

NRVs for Australia and New Zealand consist of a recommended adequate intake (AI) and upper level of intake (UL) for vitamin D.<sup>41</sup> Because the AI is unsuitable for assessment of adequacy of intakes in the population,<sup>42</sup> intakes were compared to the US/Canadian EAR of 10  $\mu$ g day<sup>-1</sup> recommended by the Institute of Medicine.<sup>9</sup> The Australian UL is 80  $\mu$ g day<sup>-1</sup> for all people aged  $\geq$  1 year,<sup>41</sup> whereas the Institute of Medicine recommends a UL of 63, 75 and 100  $\mu$ g day<sup>-1</sup> for those aged 1–3, 4–8 and  $\geq$  9 years, respectively.<sup>9</sup>

# Determining percentage contribution of foods to vitamin D intakes

Percentage contributions of foods to vitamin D intakes were derived using Harvest <sup>34</sup> and day 1 food consumption data. In AUSNUT, foods are organised under food group codes that become more specific as code digits increase. For example, the two-digit code '13' represents the broad group of cereal based products and dishes. The three-digit level of this broad group includes subgroups such as code 131: cakes, muffins, scones, cake-type desserts, which in turn expands to a five-digit level (e.g., code 13301: cakes and cake mixes, chocolate). Percentage contributions of two-, three- and five-digit code level food groups were estimated for both 25(OH)D 13/05/2723]. See the Terms and Conditions (https://onlinelibary.wiley.com/doi/10.1111/jhn.13002 by Nat Prov Indonesia, Wiley Online Libaray on [31/05/2723]. See the Terms and Conditions (https://onlinelibary.wiley.com/terms-and-conditions) on Wiley Online Libaray for rules of use: OA articles are governed by the applicable Creative Commons License

bioactivity factor scenarios and by NRV age/sex groups<sup>41</sup> as follows: (total vitamin D intake from a food group for all participants/total vitamin D intake from all foods)  $\times 100$ .<sup>43,44</sup>

#### Rounding

The dietary intakes and food contributor estimates are intended to represent habitual vitamin D intakes, which may vary with food and ingredient choice.<sup>45</sup> Preliminary rounding would have rendered some small values to '0', which may not reflect actual intakes over time. For example, some recipes (e.g., a mixed dish such as curry) include an 'undefined fat' ingredient. This 'undefined fat' value is an average of concentrations assigned to the various fats that may be used (e.g., oil, butter, ghee or margarine). As a minor ingredient in a mixed dish, the 'undefined fat' concentration may be close to 0, but cannot be assumed as always 0. Therefore, all values remained unrounded until all data generation steps were complete so that small concentrations, which may cumulatively contribute to intakes, were accounted for.

# Exploring the contribution of dietary supplements to vitamin D intakes

The intake of vitamin D from dietary supplements was not included in our estimates of usual intakes as a limitation of the NCI method is that it cannot make estimations from multimodal distributions.<sup>29,46</sup> However, we used the NNPAS day 1 food and vitamin D-containing supplement consumption data to estimate absolute intakes of vitamin D from food and dietary supplements on a single survey day. This was performed deterministically using the individual respondent data from the survey unit record file data, via Stata, version 15 (StataCorp)<sup>47</sup> rather than FSANZ's Harvest program. As previously described,<sup>48</sup> the vitamin D composition of dietary supplements reported as consumed was determined using the Australian Register of Therapeutic Goods<sup>49</sup> where possible; otherwise, composition data were obtained directly from manufacturers via website, telephone or email. The vitamin D contents of all dietary supplements reported as consumed were added to absolute daily intakes from food. Dietary supplements that contained vitamin D included single vitamin D supplements, vitamin D-containing multi-nutrient preparations, fish liver oils with naturally-occurring and/or added vitamin D, and fish oils with added vitamin D. These absolute intakes estimates were not compared to an EAR or UL because estimates of intake from a single day are not suitable for assessment of nutrient adequacy at the population level,<sup>42</sup> and may result in overestimation of the prevalence of intakes below the EAR and above the UL.<sup>15</sup>

#### Usual intakes of vitamin D

In the population aged  $\geq 2$  years, the mean daily usual intake of vitamin D ranged between 1.84 and  $3.25 \,\mu g \, day^{-1}$  across the age/sex groups when assuming a 25(OH)D bioactivity factor of 1 (Table 1). This increased to between 3.48 and  $6.09 \,\mu g \, day^{-1}$  when assuming a 25(OH)D bioactivity factor of 5. Children aged 2-3 years had the lowest usual vitamin D intakes and mean intakes were lower in females than males across the age groups assessed. We estimated that, across all sex and age groups, more than 90% of people had vitamin D intakes that were below their respective Australian AI  $(5-15 \,\mu g \, day^{-1}, depending on age group)$ when using a bioactivity factor of 1, and over 30% were under their respective AIs when using a bioactivity factor or 5. More than 95% of the Australian population had inadequate intakes compared to the EAR of  $10 \,\mu g \, day^{-1}$  recommended by the Institute of Medicine<sup>9</sup> for both scenarios. It was estimated that none of the population had usual intakes above  $80 \,\mu g \, da y^{-1}$ , representing the Australian UL,<sup>41</sup> or the

UL of  $63-100 \,\mu\text{g} \, \text{day}^{-1}$  recommended by the Institute of Medicine<sup>9</sup> for people aged  $\geq 1$  years for either scenario.

#### Major contributors to vitamin D dietary intakes

Including all participants aged  $\geq 2$  years and assuming a 25(OH)D bioactivity factor of 1, the greatest contributors to vitamin D intakes were 'Fish and seafood products and dishes' (18.3%; range 4.6% to 29.4%). Of these foods, 'Packed fin fish' was the main contributor (7.3%; range < 1% to 14.6%). 'Packed fin fish' largely represents canned products and includes popular products such as canned tuna as well as canned salmon, which had the highest analysed concentration of vitamin D.<sup>28</sup> 'Margarine and table spreads' also contributed more than 10% of intake (11.5%; range 6.3% to 19.7%) (Table 2). When a 25(OH)D bioactivity of five was used, the greatest contributors in the same respective order of code levels were 'Meat, poultry and game products and dishes' (26.3%; 17.8% to 30.6%), 'Eggs' (8.4%; 4.4% to 11.2%) and 'Chicken eggs' (8.3%; 4.4% to 11.2%). The greatest

**TABLE 1** Usual vitamin D intakes in the Australian population based on food consumption data from the 2011–2012 National Nutrition and Physical Activity Survey for ages  $\geq$  2 years, stratified by sex<sup>a</sup>

			<u>25(OH)D b</u>	bioactivity factor = 1 Percentile				<u>25(OH)</u>	D bioact	tivity fact ntile	or = 5			
Age group (years)	Sex	n <sup>b</sup>	Mean (µg day <sup>-1</sup> )	5th	25th	50th	75th	95th	Mean	5th	25th	50th	75 <sup>th</sup>	95th
2–3	Males	165	2.08	0.92	1.42	1.91	2.55	3.82	3.79	2.08	2.91	3.64	4.51	6.08
2–3	Females	152	1.84	0.81	1.25	1.68	2.26	3.43	3.48	1.89	2.64	3.31	4.14	5.63
4-8	Males	401	2.42	1.07	1.65	2.23	2.96	4.45	4.07	2.23	3.11	3.90	4.83	6.52
48	Females	374	2.18	0.94	1.48	1.99	2.68	4.01	3.77	2.03	2.88	3.60	4.50	6.06
9–13	Males	435	3.11	1.39	2.18	2.92	3.83	5.50	5.46	2.68	4.03	5.23	6.63	9.06
9–13	Females	426	2.86	1.20	1.92	2.63	3.54	5.32	4.89	2.37	3.55	4.64	5.93	8.29
14–18	Males	373	3.25	1.50	2.31	3.05	3.99	5.72	6.09	3.12	4.58	5.83	7.34	9.95
14–18	Females	367	2.44	0.99	1.63	2.24	3.03	4.57	4.35	2.05	3.14	4.12	5.30	7.44
19–30	Males	1,116	3.09	1.39	2.18	2.88	3.80	5.47	5.93	2.98	4.44	5.66	7.16	9.74
19–30	Females	1,072	2.70	1.11	1.81	2.48	3.35	5.04	4.69	2.24	3.40	4.45	5.71	7.98
31–50	Males	1,757	3.22	1.46	2.27	3.02	3.94	5.67	5.91	2.97	4.40	5.66	7.13	9.69
31-50	Females	1,778	2.71	1.12	1.83	2.50	3.36	5.03	4.74	2.27	3.45	4.50	5.76	8.02
51-70	Males	1,335	3.20	1.46	2.26	3.00	3.93	5.65	5.74	2.88	4.28	5.49	6.94	9.47
51-70	Females	1,379	2.84	1.18	1.91	2.61	3.51	5.26	4.85	2.34	3.53	4.59	5.89	8.21
≥ 71	Males	462	3.25	1.48	2.29	3.05	3.98	5.74	5.65	2.82	4.18	5.41	6.82	9.35
≥ 71	Females	560	2.90	1.21	1.96	2.68	3.60	5.37	4.91	2.37	3.57	4.66	5.96	8.29

Abbreviation: 25(OH)D, 25-hydroxyvitamin D.

<sup>a</sup>Data are presented as mean values.

<sup>b</sup>Weighted to the Australian population in 2011–2012.

25(OH)D bioactivity factor = 1	25(OH)D bioactivity factor = 5			
Food type	Contribution (%) <sup>b</sup>	Food type	Contribution	
Food group				
Fish and seafood products and dishes	18.3	Meat, poultry and game products and dishes	26.3	
Meat, poultry and game products and dishes	16.1	Cereal based products and dishes	14.7	
Cereal based products and dishes	14.9	Egg products and dishes	13.3	
Fats and oils	13.7	Milk products and dishes	11.6	
Egg products and dishes	9.7	Fish and seafood products and dishes	11.1	
Milk products and dishes	6.1	Fats and oils	8.1	
Non-alcoholic beverages	5.8			
Cereals and cereal products	5.2			
Food sub-group				
Margarine and table spreads	11.5	Eggs	8.4	
Packed (commercially sterile) fish and seafood	7.3	Mixed dishes where cereal is the major ingredient	7.7	
Mixed dishes where cereal is the major ingredient	6.7	Beef, sheep and pork, unprocessed	7.4	
Eggs	6.1	Dairy milk (cow, sheep and goat)	7.3	
Fin fish (excluding commercially sterile)	5.5	Poultry and feathered game	7.3	
Food				
Packed fin fish	7.3	Eggs, chicken	8.3	
Eggs, chicken	6.0	Chicken	6.8	
Monounsaturated margarine spreads, fat content ≥65 g per 100 g	5.0			

**TABLE 2** Contribution of foods and beverage types to vitamin D intakes based on food consumption data from the 2011–2012 National Nutrition and Physical Activity Survey for ages  $\ge 2$  years (n = 12,153)<sup>a</sup>

Abbreviation: 25(OH)D, 25-hydroxyvitamin D.

<sup>a</sup>Values are frequencies (%) for food and beverage types contributing  $\ge 5\%$  of total vitamin D intakes were included.

<sup>b</sup>Calculated as (total vitamin D intake from a food group for all participants/total vitamin D intake from all foods)  $\times 100$ .

contributors varied by sex and age group, and according to the bioactivity factor assigned to 25(OH)D (Table 3). When assuming equal bioactivity of vitamers, fortified foods (dry beverage flavourings, breakfast cereal and margarine) were major contributors to vitamin D intakes in Australian children aged 2–18 years. When a 25(OH)D bioactivity factor of 5 was applied, non-fortified foods were the major contributors across the all sex and age groups.

# Absolute intake of vitamin D from food and dietary supplements

Of 12,153 respondents with day 1 food consumption data, 2,039 reported taking a supplement that contained vitamin D. The mean (95% confidence interval [CI]) absolute intake of vitamin D from food on day 1 was 2.95 (95% CI = 2.86-3.04) µg, increasing to 5.27 (95%)

CI = 5.05-5.48) µg with vitamin D from dietary supplements added (see Supporting information, Table S1). The lowest mean absolute intake of vitamin D from food and dietary supplements combined was seen in females aged 2-3 years  $(2.19 \,\mu g \, day^{-1}; 95\%)$  $CI = 1.83-2.55 \,\mu g \, day^{-1}$ ) and was greatest for females aged  $\geq$  71 years (9.50 µg day<sup>-1</sup>; 95% CI = 8.26– 10.74  $\mu$ g day<sup>-1</sup>). With dietary supplements included, mean absolute intakes remained below  $5 \mu g day^{-1}$  for all age groups  $\leq$  18 years and for males aged 19–70 years, and remained below  $10 \,\mu g \, day^{-1}$  for all sex and age groups assessed (see Supporting information, Table S1). Among supplement users only, the mean absolute intake from food and dietary supplements was 17.72 (95% CI = 16.72-18.72) µg day<sup>-1</sup>, ranging from 4.82 (95% CI = 3.75-5.91) µg day<sup>-1</sup> in females aged 2-3 years to 24.00 (95% CI = 21.37-26.64)  $\mu$ g day<sup>-1</sup> in females aged  $\geq$  71 years (see Supporting information, Table S2).

209

(%)

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HND

Age (years)	25(OH)D bioactivity factor = 1	25(OH)D bioactivity factor = 5	<b>TABLE 3</b> Highest food and beve           contributors to vitamin D intakes for
Male			consumption data from the 2011–20
2–3	Fortified dry beverage flavourings	Milk, cow, fluid, regular whole, full fat	National Nutrition and Physical Ac Survey $(n = 12,153)$
4–8	Fortified dry beverage flavourings	Milk, cow, fluid, regular whole, full fat	
9–13	Fortified dry beverage flavourings	Milk, cow, fluid, regular whole, full fat	
14–18	Breakfast cereal, mixed grain, fortified, sugars >20 g per 100 g	Eggs, chicken	
19–30	Packed fin fish	Eggs, chicken	
31–50	Eggs, chicken	Eggs, chicken	
51-70	Eggs, chicken	Eggs, chicken	
>70	Monounsaturated margarine spreads (fortified)	Eggs, chicken	
Female			
2–3	Fortified dry beverage flavourings	Milk, cow, fluid, regular whole, full fat	
4–8	Monounsaturated margarine spread (fortified); Packed fin fish	Milk, cow, fluid, regular whole, full fat	
9–13	Breakfast cereal, mixed grain, fortified, sugars >20 g per 100 g	Chicken	
14–18	Breakfast cereal, mixed grain, fortified, sugars >20 g per 100 g	Eggs, chicken	
19–30	Fortified dry beverage flavourings	Egg dishes, savoury	
31–50	Packed fin fish	Eggs, chicken	
51-70	Packed fin fish	Eggs, chicken	
>70	Packed fin fish	Packed fin fish	

Abbreviation: 25(OH)D, 25-hydroxyvitamin D.

#### DISCUSSION

Usual mean intakes of vitamin D from food were low in the Australian population, at  $<3.5 \,\mu g \, day^{-1}$  across all sex and age groups, assuming a bioactivity factor of 1 for the D vitamers (vitamin  $D_3$ , 25(OH) $D_3$ , vitamin  $D_2$  and 25(OH)D<sub>2</sub>). Usual vitamin D intakes were lowest in younger age groups and lower in females than males. The overall amount of food consumed may play a role in these differences; however, the EAR of  $10 \,\mu g \, day^{-1}$ recommended by the Institute of Medicine<sup>9</sup> remains the same for all people aged  $\geq 1$  years and the mean usual vitamin D intake is estimated as substantially below this recommendation across the age and sex distribution in the Australian population. Our research to date shows that those particularly at risk of vitamin D deficiency in Australia include young adults,<sup>3</sup> Aboriginal and Torres Strait Islander people living in remote areas<sup>50</sup> and people born outside Australia or the main English-speaking countries.<sup>2</sup> It is not possible to determine whether the population groups with the lowest usual vitamin D intakes correspond with those with lower vitamin D status because there has not been a national survey of circulating 25(OH)D concentrations in Australian children aged < 12 years.

Our estimate of usual vitamin D intakes in the Australian population remained relatively low even when a 25(OH)D bioactivity factor of 5 was applied. The 25(OH) D bioactivity factor of 5 was used in our secondary model because it is used in a small number of national food composition databases. It is generally accepted that 25(OH) D is more bioactive than vitamin D; however, the extent to which it is has not yet been confirmed, and it has been suggested that the vitamers should be considered equal until definitive data are available.<sup>21</sup> Here, we have shown that vitamin D intakes from food in Australia remain low even under the likely best case scenario of 25(OH)D being up to five times more bioactive that vitamin D.

Dietary supplements also contribute to intakes of vitamin D and are important to consider when estimating baseline intakes. Our earlier study showed that approximately 17% of Australians aged  $\geq 2$  years had consumed a vitamin D-containing supplement in the 24 h preceding the first 24-h dietary recall interview.<sup>48</sup> Only 4% of participants had taken a single vitamin D supplement (typical daily dose =  $25 \mu g$ ). Approximately 3% of participants had taken a vitamin D-containing calcium supplement, 11% had taken a vitamin D-containing multivitamin-multimineral supplement and 1% had taken a vitamin D-containing fish oil preparation. The median (range) doses for these preparations, in the same respective order, were 5 (0.1-25), 5 (1-25) and 5  $(0.1-25) \mu g \text{ day}^{-1}$ . Less than 0.5% of participants had taken fish liver oil with a median (range) dose of 2 (0.2–6)  $\mu$ g day<sup>-1</sup>.<sup>48</sup> We found that, for the majority of the sex and age groups assessed, mean intakes of vitamin D from food and dietary supplements were not substantially greater than intakes from food only. The greatest difference between absolute intakes from food only and with dietary supplements was seen in females aged > 50 years (increase of 5–6  $\mu$ g day<sup>-1</sup>), who have greater risk of osteoporosis with increasing age. Among supplement users only, there was a greater difference between absolute intakes from food only and from food and dietary supplements. These nationallyrepresentative data suggest that, in 2011–2012, the majority of Australians either did not use vitamin Dcontaining dietary supplements, did not report it on the day surveyed as a result of it being infrequently consumed, or did not take a daily dose sufficient to increase their dietary intake to recommended levels.

Our results indicate that the majority of Australians consume less vitamin D from food than people in the USA, Canada and some European countries. This was despite all four D vitamers being measured in all sampled foods, irrespective of animal or plant origin, and accounted for in our estimates. Conversely, food composition data used for US,<sup>4,18,19</sup> Canadian<sup>5,20</sup> and some European<sup>10–17,51</sup> intakes estimates included fewer vitamers and/or not all vitamers were measured in all foods. Caution is needed when comparing intake estimates across countries; however, the gap between intakes in these regions and intakes in Australia could be conceivably greater if the compositional datasets used were of similar scope.

This gap may be a result of differing fortification practices. Vitamin D is found naturally in relatively low concentrations in a narrow range of foods.<sup>7</sup> Because it can therefore be difficult for many people to meet dietary vitamin D requirements through naturally-occurring food sources,<sup>7</sup> fortified foods are important sources of vitamin D in countries where they are available.<sup>4,5</sup> In Australia, only margarine is mandatorily fortified. Although vitamin D is permitted to be added via voluntary fortification to low fat milk, dairy alternatives **HND** 

and breakfast cereals, vitamin D fortification of these products is not routine. By contrast, foods such as dairy products, dairy alternatives and juice are commonly fortified with vitamin D in the USA and Canada,<sup>9</sup> whereas fortification practices vary across European countries.<sup>7</sup> In Finland, the proportion of the population with serum 25(OH)D concentrations > 50 nmol  $L^{-1}$ increased from 44% to 91% following fortification of fluid milk products and fat spreads in 2003.<sup>26</sup> Moreover, greater improvements in circulating 25(OH)D concentrations were seen in those with concentrations <30 nmol L<sup>-1</sup> than those with concentrations  $\geq 50 \text{ nmol } L^{-1}$ .<sup>26</sup> Nutrition policy informed by modelling food and nutrient intakes could assist in determining potential fortification strategies to optimise dietary intakes and reduce the prevalence of vitamin D deficiency in Australia.

We estimated that more than 95% of Australians aged  $\geq 2$  years had vitamin D intakes below the EAR of  $10 \,\mu g \, da y^{-1}$  recommended by the Institute of Medicine. In light of this, population-level strategies may be needed to address the low population vitamin D intakes and concomitant low vitamin D status in Australia. However, it should be noted that the aforementioned EAR recommended for the USA and Canada is based on minimal sunlight exposure,<sup>9</sup> and most Australians have more opportunity for sun exposure than people living in North America. Despite year-round opportunity for sun exposure in many regions of the country, the high prevalence of vitamin D deficiency<sup>2,3</sup> implies that most Australians do not produce sufficient vitamin D via this source. Even higher prevalence of low vitamin D status, together with low vitamin D intakes, have been reported for some Northern African and Middle-Eastern countries with ample opportunity for sun exposure.<sup>7,52,53</sup> Skin pigmentation, cultural clothing practices, sun/heat avoidance and protective measures against skin damage and skin cancer may play a role in the relatively high prevalence of vitamin D deficiency in sunny countries. In Australia, vitamin D dietary supplements may be needed on an individual basis by people with increased dietary vitamin D requirements,<sup>9,41</sup> such as the elderly,<sup>7</sup> and others at high risk of vitamin D deficiency. However, relatively few Australians (particularly younger people) use dietary supplements,<sup>48</sup> and they may not be effective as a population-wide solution to vitamin D deficiency. Increasing the dietary supply of vitamin D through fortification, on the other hand, is an alternative strategy that could potentially safely improve mean serum 25(OH)D concentrations across the whole population.

Globally, the methods outlined here may be useful to other countries that have, like Australia, lacked comprehensive vitamin D food composition data and are building a new system for estimating usual vitamin D intakes from food. Nationally, our new data on usual vitamin D intakes in the Australian population will allow investigation of potential associations between vitamin D intakes and various health conditions, as well as how IHND

health conditions affect intakes, which may be used to inform public health nutrition campaigns. In combination with our new vitamin D food composition data, the data will also allow researchers to predict the effect of adding various concentrations of vitamin D to various foods on circulating 25(OH)D concentrations, and to develop a potential option to improve vitamin D status at the Australian population level.

The major strengths of the present study were the use of nationally representative food consumption data and comprehensive food composition data that included four D vitamers measured using a sensitive and specific liquid chromatography with triple quadrupole mass spectrometry method. Food composition data were based on analytical values for major foods in the form that they would usually be consumed, such as cooked meat and seafood. However, these intakes estimates are subject to the usual limitations of self-reported food consumption data, such as recall bias and measurement error,<sup>54</sup> and of food composition data, such as sampling and measurement uncertainty.<sup>28</sup> Although we did not include vitamin D from dietary supplements in the estimation of usual intakes because of limitations of the NCI method, we produced estimations of absolute vitamin D intakes from food and dietary supplements from day 1 consumption data only. Our findings suggest that vitamin D supplement use in Australia did not sufficiently compensate for low vitamin D intakes from food for the majority of Australians. Because of the age of NNPAS data, food consumption and supplementation practices may have changed over time; however, there are no more recent nationally-representative data available to confirm this.

We have presented estimates of usual vitamin D intakes for the Australian population using nationally representative food consumption data and comprehensive food composition data. Our new data show that vitamin D intakes from food in Australia are lower than international recommendations and lower than in the USA, Canada and many European countries. Given the prevalence of low vitamin D status in the population, despite relatively good opportunity for sun exposure, strategies to address low vitamin D intakes from food are needed in Australia. This could include measures such as food-fortification or -biofortification to increase the dietary supply of vitamin D. Our estimate of vitamin D intakes will allow modelling of various food fortification scenarios to inform nutrition policy for improving vitamin D status in the Australian population.

#### AUTHOR CONTRIBUTIONS

Lucinda J. Black, Mairead Kiely, Caryl A. Nowson, Anna Rangan, Judy Cunningham, Paul Adorno and Paul Atyeo designed the research. Paul Atyeo and Paul Adorno provided essential materials. Eleanor Dunlop, Julie L. Boorman, Tracy L. Hambridge and Jessica McNeill conducted research and analysed data. Eleanor Dunlop, Julie L. Boorman, Tracy L. Hambridge and Jessica McNeill wrote the paper. Lucinda J. Black, Anthony P. James, Anna Rangan and Judy Cunningham supervised the research. Lucinda J. Black, Anthony P. James, Mairead Kiely, Caryl A. Nowson, Anna Rangan, Judy Cunningham, Paul Adorno and Paul Atyeo reviewed and edited the paper. Lucinda J. Black had primary responsibility for the final content. All authors read and approved the final version of the manuscript submitted for publication.

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#### **CONFLICT OF INTERESTS**

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. The authors affirm 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 may be found in the online version of the article at the publisher's website.

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#### PRINCIPLES OF NUTRITION AND DIETETICS

## Exploring stakeholder experiences of dietetic service and care delivery: A systematic qualitative review

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#### Abstract

Background: There is limited understanding of patients' and healthcare professionals' perceptions and experiences of receiving and delivering dietetic care, respectively. This systematic review of the literature used qualitative synthesis to explore the perceptions and experiences of multiple stakeholders involved in the delivery of nutrition care and dietetic service.

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Methods: MEDLINE, Embase, CINAHL, Cochrane Library, Scopus, ISI Web of Science, PsycINFO and ProQuest were systematically searched. Study characteristics and perceptions of stakeholders regarding nutrition care services were extracted. Qualitative synthesis was employed and thematic analysis conducted.

**Results:** Five themes were identified from 44 studies related to stakeholders' perceptions of dietetic services. Studies included quantitative, qualitative and mixed methods involving patients, families, dietitians and other healthcare professionals. The themes were (1) patients desiring a personalised approach to nutrition care; (2) accessing dietetic service; (3) perceived impact of nutrition care on the patient; (4) relationships between stakeholders; and (5) beliefs about nutrition expertise. Two themes were specific to patients; these were the desire for individualised care and the impact of nutrition care. Within each theme perceptions varied with patients' views often contrasting with those of dietetic service providers.

Conclusions: Experiences of dietetic service do not always meet stakeholder expectations which impacts on patient engagement. Seeking stakeholder input is imperative to design dietetic services that engage patients in positive and supportive clinical partnerships.

#### **KEYWORDS**

clinical practice, dietary advice, qualitative, study design and analysis

#### Key points

- · Stakeholder perceptions of dietetic service and care delivery included themes around a need for a personalised approach to nutrition assessment and intervention, enablers and barriers to accessing dietetic services, the importance of relationships between stakeholders and a range of beliefs about nutrition expertise.
- · Experiences of dietetic services did not always meet stakeholder expectations which impacted on patient engagement.

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• Stakeholder perceptions of dietetic service and care delivery provide valuable insights which can be used to better meet patient, healthcare service and community needs, as well as inform dietetic curricula to prepare graduates for authentic patient-centred care.

Engaging patients in the design and delivery of health services is an important feature of hospital safety and quality systems, and accreditation frameworks. Quality and safety guidelines, such as the US National Quality Strategy<sup>1</sup> and the UK National Health Services Institute for Innovation and Improvement,<sup>2</sup> emphasise the importance of patient engagement within healthcare services. Encouraging patient input is required at all levels, including planning, design, delivery, measurement and evaluation of healthcare.<sup>3</sup>

Traditionally, patient perceptions of the health care they receive have been determined by surveys that measure satisfaction with service delivery.<sup>4</sup> Over the past two decades, there has been a shift from measuring satisfaction with care to seeking patients' experiences of care. Patient engagement in decision making about healthcare has become a cornerstone of 'quality of care'.<sup>5</sup> Patient engagement can change healthcare practice, including informing the development of education materials, clinical care tools and healthcare policies and guidelines.<sup>5</sup> Patient engagement can enhance clinical care and service delivery as well as contribute to organisation design and governance.<sup>5</sup> However, the delivery of nutrition care is frequently evaluated in terms of clinical outcomes rather than overall health outcomes or patient engagement and consumer feedback. Examples include prevalence of malnutrition or nutrition risk,<sup>6–8</sup> nutrient intake<sup>9,10</sup> or anthropometric and biochemical markers in chronic disease management.9,11

Exploring the experiences of healthcare professionals delivering care also has the potential to establish meaningful patient and practitioner relationships and contribute to service improvements.<sup>12</sup> Well-designed healthcare services should consider a range of stake-holder experiences, including those of patients and healthcare providers. Other stakeholders may include universities that train healthcare professionals or conduct health-related research and government bodies where these partnerships co-create models of care across many levels of the healthcare system.<sup>13</sup>

Exploring a range of experiences of dietetic service and care delivery is required to improve utilisation of referrals, engagement with dietary interventions, lower attrition and improve our understanding of the story behind the clinical outcome data. Insights from people seeking nutrition care and those providing dietetic services, as well as those who interact with service providers, could be used to design services that lead to improved patient and health outcomes. We conducted a systematic review and qualitative synthesis<sup>14–16</sup> to explicitly answer the research question: what are stakeholders' perceptions and experiences of the delivery of dietetic service across healthcare settings?

#### METHODS

The review strategy aimed to identify the full and diverse range of published literature, allowing for a broader range of articles to be included than in a more traditional review. An objective approach was used to systematically search the literature to enable systematicity and transparency in reporting the design and results of this review. A qualitative synthesis of all studies was completed using techniques from qualitative research to guide a dynamic and iterative approach to the review process due to the heterogeneity of studies that investigate perceptions and experiences of a phenomenon of interest.<sup>14–16</sup>

The review was registered with PROSPERO, the international prospective register of systematic reviews (registration CRD42019129171).<sup>17</sup> The Preferred Reporting Items for Systematic Reviews and Metaanalyses (PRISMA) framework was utilised to report the number of studies identified and screened and the criteria used to determine eligibility for inclusion and for reporting the methods and outcomes<sup>18</sup> (see checklist). The review is reported according to the ENhancing Transparency in REporting the synthesis of Qualitative research (ENTREQ) framework<sup>19</sup> (see checklist).

#### Search strategy

The search strategy was developed in consultation with a specialist research librarian and senior dietetics researchers with backgrounds in research and clinical service delivery. Eight databases were systematically searched: MEDLINE, Embase, CINAHL (EBSCO host), Cochrane Library, Scopus, ISI Web of Science, PsycINFO and ProQuest in December 2020. The search was updated in August 2021 to capture recent publications. These were supplemented by hand searching of reference lists of articles retrieved. The full MEDLINE search strategy is included in Supplementary Information: Table 1. Search results were exported into ENDNOTE X8 software<sup>20</sup> for screening and duplicate removal. Screening was performed independently by two researchers using the Covidence platform.<sup>21</sup> The search was structured in accordance with the PICO framework (population, intervention, comparator, outcome). Search

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 TABLE 1
 PICOS criteria for studies included in a systematic qualitative review exploring stakeholder experiences of dietetic service and care delivery

Parameter	Inclusion criteria
Participants/population	Stakeholders including patients, families, carers, consumers, dietitians, health professionals, educators, food and support services and allied health assistants.
Intervention/exposure	Measures of satisfaction with, or reported perceptions about, an encounter or service attributed solely to a dietitian across any healthcare setting which may include perspectives towards a nutrition or dietary intervention.
Comparator	Not applicable
Outcome	Insight into the perspective of multiple stakeholders towards the dietetic service and nutrition care they encounter.
Study design/type	Interventional, descriptive and observational studies

terms included subject headings related to stakeholders, terms related to experiences and combinations of terms related to nutrition care. Table 1 highlights the population, intervention, comparator, outcome, study design categories used to form the research question.

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#### Eligibility criteria

Original research studies were eligible for inclusion if they included measures of satisfaction with, or reported perceptions about, an encounter or service attributed solely to a dietitian across any healthcare setting and involved one or more of the following stakeholders: patients, families, carers, consumers, dietitians, health professionals, educators, food and support services, and allied health assistants. Studies were excluded if they reported nutrition care delivered by a health professional who was not a dietitian, the dietetic component of care delivery could not be extracted independently or they were not primary full research papers, for example, conference abstracts. Articles were restricted to those in the English language with no date restrictions applied.

#### Selection process and data extraction

All records identified were screened for eligibility based on the information in the title and abstract by two independent researchers with disagreements being resolved between these two researchers. The full text of all publications that appeared to meet eligibility screening were then screened in duplicate for inclusion. Any discrepancy in selection between the two researchers was resolved by reflection and discussion. Studies were excluded if they did not focus on nutrition care or dietetic service; the dietetic service component was impossible to extract or the study did not include dietitians in the nutrition care model.

Study characteristic data from included articles were extracted by one author and cross-checked by the second author. Data extracted included setting, study design, study aim, participant characteristics, data collection techniques, important results and implications for nutrition care and dietetic service delivery.

#### Synthesis of results

Sequential synthesis design was employed to synthesise results, where the quantitative and qualitative data were analysed separately, and the data converged according to interpretive synthesis principles.<sup>16,22</sup> Thematic analysis of how dietetic service was perceived by multiple stakeholder groups and its relevance to specific groups was conducted.<sup>15,16</sup> One author independently extracted data and conducted coding of all studies and commenced theme development, the second author independently, extracted data and conducted coding, on a random selection of six studies. The data were coded using an inductive approach to develop a synthesising argument: looking to interrogate rather than aggregate concepts and themes.<sup>16</sup> During initial coding, codes were grouped into categories that formed the coding structure and were used to inform theme development. The qualitative data analysis software, NVIVO,<sup>23</sup> was used to facilitate coding. The two authors came together regularly throughout the coding process for clarification and iterative discussion of themes. When discussing emerging themes, they applied a critical approach to each other's interpretation to reach consensus. The researchers were qualified dietitians with wide experience working in dietetic service across a diverse range of public and private healthcare settings, as well as in research and higher education.

#### Quality appraisal

Qualitative studies were appraised using the Critical Appraisal Skills Programme tool for qualitative studies checklist.<sup>24</sup> Quantitative studies were appraised using the

Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-Sectional Studies.<sup>25</sup> One author appraised all studies, and the second author independently assessed 19 studies to verify appraisal outcomes. In this review due to the heterogeneity of studies, quality appraisal was employed to improve understanding of study rigour and not to measure and compare the strength of studies.

#### RESULTS

A flow chart of identified and included studies is shown in Figure 1. A total of 44 studies were included comprising of 34 qualitative, 6 quantitative studies and 4 studies combined qualitative and quantitative methodologies. The characteristics of the included studies are summarised in Table 2.

Of the included papers, 27 exclusively explored the experiences of patients, consumers and parents of children who received dietetic nutrition care.  $^{26,28-30,36,37,39,40,42,44-50,52-55,59,62,65-69}$  Four studies investigated dietitians experiences of delivering nutrition care,  $^{32,51,56,60}$  and four studies explored the experiences of both patients and dietitians.  $^{34,41,63,66}$ 



for Nine studies explored the experiences of healthcare staff groups who interacted with dietitians and nutrition care team, including multidisciplinary healthcare teams,  $^{31,35,43,57,58}$  general practice health professionals,  $^{27,61}$  obstetricians and gynaecologists,  $^{64}$  general hospital staff and staff at an industrial steel works.  $^{38}$  Settings from included studies were acute hospitals  $(n = 23), ^{26,28,31,35,36,39,42,43,45-47,49,50,52-55,57,58,64,66-69)$ 

(n = 23), where (n = 7), (n = 23), (n = 3),  $(n = 1)^{38}$  and a mental health service (n = 1). Five studies included multiple settings, including hospitals, community health centres and private practices. (n = 3), (n = 3)

Nutrition care was related to the following health issues and medical conditions: cancer,  $^{28,36,43,45-47,49,53,65}$  type 2 diabetes,  $^{11,30,60,61}$  overweight and obesity,  $^{26,27,33,44,48,67,69}$  prenatal care,  $^{64}$  mental health,  $^{40,49}$  renal disease,  $^{50,51,54,55,66}$  coeliac disease,  $^{52}$  post traumatic brain injury  $^{35}$  and lifestyle and chronic diseases.  $^{29,31,32,38,39,41,56}$  The studies that included obesity also involved patients in the context of bariatric surgery  $^{26}$  and women with obesity in antenatal care  $^{44}$  and postnatal care.  $^{67}$ 



FIGURE 1 Flow diagram of the literature search and filtering results for a systematic qualitative review exploring stakeholder experiences of dietetic service and care delivery
Author, year, country	Phenomenon/research questions	Study setting	Participants	Study design	Stakeholder perceptions
Aarts et al., 2017, <sup>26</sup> Canada	To understand patient experiences of a bariatric surgery programme to gain insight into how to improve and optimise mandatory follow- up care.	Acute metropolitan hospitals.	Patients $\ge 18$ years old who had surgery through a multidisciplinary bariatric surgery programme, $n = 46$ .	Qualitative study using semi- structured telephone interviews.	Effective follow-up care cannot be solely measured by anthropometric and adherence outcomes. Follow-up care needs to be accessible and individualised to the patient.
Abbott et al., 2021, <sup>27</sup> United Kingdom	To explore general practice healthcare professional's experiences and perceptions of dietitians in the context of obesity management.	England and Scotland.	General practice healthcare professionals, $n = 20$ .	Qualitative study using semi- structured interviews.	Dietitians were experts in managing obesity. Integrating dietitians into general practice would improve access.
Alberda et al., 2017, <sup>28</sup> Canada	To explore perspectives on nutrition care of patients with head and neck or oesophageal cancer in the context of their illness, medical treatment and recovery.	Tertiary care hospital and local cancer care clinic.	Patients with ocsophageal $(n = 10)$ , or head and neck cancer $(n = 10)$	Descriptive qualitative study using semi-structured interviews.	Need individualised complex support with resources available inside and outside the walls of the hospital or cancer care centre.
Ball et al., 2014, <sup>29</sup> Australia	To explore individual's preferences regarding the provision of nutrition care from Australian health professionals and the factors influencing this.	Primary health care.	Patients ≥40 years with at least one self-reported lifestyle- related chronic disease, or modifiable risk factor for lifestyle-related chronic disease, <i>n</i> = 38.	Qualitative interview design.	General practitioners were preferred providers of nutrition care.
Ball et al., 2016, <sup>30</sup> Australia	To explore the perceptions of patients recently diagnosed with type 2 diabetes regarding nutrition care received from dicitians.	Primary health care.	Patients diagnosed with type 2 diabetes in the previous 4 months, $n = 10$ .	Longitudinal interpretive, qualitative design using semi- structured telephone interviews.	Dietetic care is overwhelming, not helpful and desired more individualised care.
Barnes et al., 2018, <sup>31</sup> USA	To explore barriers to referral to dietitian by primary care professionals and perceptions related to intra-organisational factors that influence the initiation of community health medical nutrition therapy referrals.	Primary health care.	Health professionals at primary care clinics, $n = 25$	Exploratory multiple case study designs using focus groups.	Unclear about the role and function of community health dietitians. Accessibility constrained by insurance and patient readiness to change.
Beckingsale et al., 2016, <sup>32</sup> New Zealand	To describe dietetic services being delivered and dietitians' perceptions of the factors that influence their ability to deliver an optimal service in general medical practices.	Primary health care.	Dictitians delivering dietetic services in primary health centre (PHC) – for women, including Māori and Pacific peoples, $n = 12$ .	Qualitative study involving semi- structured, face-to-face interviews.	Dietitians need to be recognised as being part of the general practice to work effectively.

TABLE 2 Characteristics of studies included in a systematic qualitative review exploring stakeholder experiences of dietetic service and care delivery

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Stakeholder perceptions	Preference for prescriptive diet plans. Location and available parking enhance access. Dietitians viewed as polite and courteous.	Dietitians perceived empathy was highly important, and they actively strived to achieve this. Patients perceived dietitians require four main communication competencies: interpersonal communication, professional values, counselling skill.	Dietitians were regarded as the expert on nutrition for patients with TBI. Nurses felt a strong ownership over nutrient delivery and felt that they were best positioned to manage nutrition needs overall.	Experiences of being provided with individual dietetic input and dietary counselling was generally viewed as positive.	Dietitians were helpful and informative and assisted the patients in understanding their diet but only 50% of respondents said that dietitians were visible to patients.	(Continues)
Study design	Mixed methods study using client clinic record review and a satisfaction survey adapted from an existing instrument.	Two phase sequential qualitative- quantitative mixed methods design using interviews, focus groups and survey instrument.	Qualitative exploratory methodological approach using semi-structured interviews.	Exploratory study adopted van Manen's hermeneutic phenomenological philosophical approach using semi-structured, in-depth interviews.	Market-based study using survey administered via telephone.	
Participants	Overweight or obese adults with no reported comorbidities who attended university-run weight loss clinics, $n = 61$ .	Australian dietitians, $n = 46$ . Adult patients, who had recently consulted with a dietitian, $n = 34$ . Dietitian members of Dietitians Australia, $n = 258$ .	Medical consultants, registrar physicians and nurse practitioners in the areas of intensive care, neuro surgery and trauma with $\ge 12$ months experiences and $\ge 10\%$ of their workload managing patients with TBI, $n = 34$ .	Patients >18 years, with pancreatic cancer, $n = 13$ .	Adults living in a mainly urban county in Ohio, $n = 223$ .	
Study setting	Student-led weight loss clinics.	Hospitals, community- based health services and private practices.	Major metropolitan neurotrauma hospitals.	National Health Services Trusts, England	Urban community.	
Phenomenon/research questions	To assess the client satisfaction and weight loss outcomes of two student-focused dietetic outpatient weight loss clinics.	To examine the perceptions of both dietitians and their patients about dietitians' skills and attributes for nutrition education of individuals.	To explore the views and attitudes of health practitioners involved in the decision-making processes around nutrition therapy throughout hospitalisation for patients with total brain injury (TBI). To develop an understanding of how the experiences of health practitioners have informed their views of the role of nutrition and identify potential barriers and facilitators in providing adequate nutrition.	To explore the views and experience of patients with operable pancreatic cancer about food and weight loss, perioperatively and following surgical treatment.	To determine consumer perceptions of the quality of hospital food, food-related service and clinical service and the importance of these factors when hospitalised or selecting a hospital for medical care.	
Author, year, country	Burrows et al., 2013, <sup>33</sup> Australia	Cant and Aroni, 2008, <sup>34</sup> Australia	Chapple et al., 2018, <sup>35</sup> Australia	Cooper et al., 2015, <sup>36</sup> England	DeLuco and Cremer, 1990, <sup>37</sup> USA	

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	urnal of Human Nutrition and Dietetics							
Stakeholder perceptions	Experience with dietetic service was nonpatronising, interesting and fun and supported their goal setting.	Perception of dietitians was influenced by patients' physicians. Patients described dietitians as nutrition experts but unsure of their qualifications.	Patients reported that the act of a physician referring to a dietitian is a strong factor in adherence to dietetic treatment.	Dietitians perceived that they should focus less on achieving short-term nutritional goals and more on guiding lifestyle changes.	Co-locating a dictitian to the service promoted optimal nutrition and effective health care for consumers, carers and clinicians.	Consumers and carers felt that the dietitian enhanced their low levels of healthy eating literacy.	Patients expected dietitians to adopt a patient-centred approach which might be either patient or practitioner led and to take	account of what they want from consultations, adapting these to meet their individual requirements.
Study design	Qualitative study using semi- structured, face-to-face interviews.	Qualitative study using patient- based focus groups and on one-on-one interviews with dietitians.			Exploratory study using semi- structured interviews.		Qualitative study using semi- structured interviews and focus groups.	
Participants	Employees at three occupational departments, $n = 15$ .	Patients aged 35-60 years who had consulted with dictitian from the Jewish and Muslim groups.	Clinical dietitians $(n = 12)$ working with low to middle socioeconomic patient populations.	Dietitians $(n = 5)$ who supervise clinical dietitians from the district.	Consumers and carers $(n = 8)$ , who had engaged with or were aware of the dietetic service.	Clinicians, $n = 9$ , at the mental health service who had engaged with a dictitian.	Dietitians working in three NHS Trusts located in two cities in south of the United Kingdom, $n = 33$ .	Patients >18 years attending routine dietetics outpatient appointments for a long-term condition, $n = 41$ .
Study setting	Industrial steel works & General Hospital, Wales.	Maccabi Health Services, Israel.			Community mental health service, Melbourne Australia.		National Health Service Trusts.	
Phenomenon/research questions	To explore participants' experiences of a workplace lifestyle intervention programme designed to reduce risk of developing cardiovascular disease and type 2 diabetes mellitus (T2DM).	To ascertain the role of the dietitian-patient relationship and the counselling approach in influencing the individual patients' decisions to adhere to treatment by continuing or not to adhere to	terminating their nutritional treatment.		To describe access to and key stakeholder perspectives of the Accredited Practising Dietitian (APD) collocated in an adult	community mental health service.	To explore patients' experiences of dietetic consultations.	
Author, year, country	Di Battista et al., 2017, <sup>38</sup> Wales	Endevelt and Gesser- Edlesburg, 2014, <sup>39</sup> Israel			Furness et al., 2018, 40 Australia		Hancock et al., 2012, <sup>41</sup> England	

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Stakeholder perceptions	Patients valued dietitians coordinating and working collaboratively with the other healthcare professionals. Care was of high quality when	ditetutians used active insteming and empathy. Dietitians are core and experts in the care of patients with head and neck cancer.	Positive experiences with dietetic service and dietitians had relevant expertise.	Overall satisfaction, the three domains of satisfaction (perceived benefit, interpersonal skills and staff presentation) and two independent statements (helpfulness and expectation) were rated highly by patients.	Higher satisfaction was found in the NI group related to parameters of staff interpersonal skills, perceived health benefits, staff presentation skills and for overall satisfaction with nutrition services.	89% of patients felt the services were good and very good. Nutrition information and advice received by patients was rated as helpful and met their expectations.	(Continues)
Study design	Mixed methods exploratory study using medical record review, patient satisfaction survey and semi-structured interviews.	Qualitative study using semi- structured interviews.	Phenomenological study using one-to-one, in-depth unstructured interviews.	Pilot randomised control trial with a post-trial patient satisfaction with clinical nutrition service questionnaire.	Randomised control trial with a post-trial patient satisfaction with clinical nutrition service questionnaire.	Observational, cross-sectional study using a modified patient satisfaction with clinical nutrition services questionnaire.	
Participants	Patients >70 years seen by a dictitian for malnutrition assessment. Survey, $n = 56$ , interview, $n = 10$ .	Healthcare professionals working in head and neck cancer teams, $n = 46$ .	Pregnant women with body mass index (BMI) > 30 referred to a hospital based antenatal dietetic service, $n = 15$ .	Patients undergoing autologous SCT period Patients with diagnosis of haematological malignancy treated with high-dose chemotherapy, $n = 37$ .	Patients $\ge 18$ year commencing radiotherapy, $n = 58$ .	Patients >18 years, $n = 18$ .	
Study setting	Acute and subacute hospitals.	Radiotherapy departments at three hospitals and one private cancer centre.	Antenatal dietetic service.	Acute hospital	Acute metropolitan radiation oncology service.	Chemotherapy unit, acute metropolitan hospital.	
Phenomenon/research questions	To identify patient-centred quality indicators of dietetic services from the perspectives of older malnourished patients.	To explore how the role of the dietitian is perceived and enacted to different head and neck cancer teams from the perspective of healthcare professionals.	To gain a greater understanding of women's direct experiences and views on care received to inform service development in an antenatal dietetic service.	To report patient satisfaction with a clinical nutrition service delivered by a dictitian in stem cell transplantation (SCT) recipients in a pilot randomised-controlled trial examining the potential benefit of extended nutrition care compared to usual nutrition care.	To investigate the impact of nutrition intervention vs usual care in ambulatory oncology patients receiving radiotherapy to the gastrointestinal or head and neck area.	To assess the satisfaction with nutrition interventions of patients with cancer receiving outpatient chemotherapy.	
Author, year, country	Hazzard et al., 2017,42 Australia	Hazzard et al., 2021, <sup>45</sup> Australia and USA	Heslehurst et al., 2017, <sup>44</sup> England	Hung et al., 2014, <sup>45</sup> Australia	Isenring et al., 2004, <sup>46</sup> Australia	Isenring et al., 2008, <sup>47</sup> Australia	

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Stakeholder perceptions	Patients who had received a dietitian review recorded a higher satisfaction with nutrition services than the handout group meeting.	Dietitians listened and patients valued the advice provided. Some patients expressed disappointment in the wait for service and lack of individualisation of advice provided.	Insufficient dietary information and support was provided by the dietitian, and patients were unprepared for changes to diet and weight due to undesirable impacts of cancer treatment on diet and physical activity.	Patients and carers described learning to make sense of renal diet information as emotionally challenging. Patients perceived that dietitian provided didactic advice without explanation. Conflicting advice from many sources was confusing and caused anxiety. Patients valued access to the same dietitian during critical stages and meal plans to be individualised to their personal circumstances.	Resources were limited or inadequate to provide dietetic advice. Need to establish trust and demonstrate empathy with their patients for productive therapeutic relationships.
Study design		Qualitative study using semi- structured, one-on-one interview.	Qualitative study using semi- structured interviews.	Qualitative study using semi- structured interviews.	Qualitative study using semi- structured interviews.
Participants	Adult patients with BMI $\geq$ 30 kgm <sup>-2</sup> , or $\geq$ 28 kgm <sup>-2</sup> with obesity-related complications attending the clinics for weight management advice, $n = 24$ .		Breast cancer patients, $n = 17$ .	Patients with CKD including pre- dialysis, peritoneal dialysis, haemodialysis or renal transplantation, $n = 26$ .	Renal dietitians working in all states and territories of Australia and New Zealand, $n = 27$
Study setting		Primary care dietetic clinics.	Metropolitan cancer centre.	Outpatient clinic.	Australia and New Zealand.
Phenomenon/research questions		To obtain views of patient with obesity attending community dietetics clinics, on the dietetic service, the outcomes of dietary treatment in terms of lifestyle change and the impact attending the dietitian had on their lives.	To explore the experiences, dietary information and support needs of women who gain weight during chemotherapy treatment.	To describe the experiences of patients with chronic kidney disease (CKD) and their carers, with respect to interpreting and implementing the renal diet, explore strategies used by patients and carers to help them make sense of, and apply renal diet information and to develop recommendations to help improve the provision of dietary education to patients.	To explore the experiences of renal dictitians regarding the process of educating patients with end stage kidney disease and to describe the strategies they perceived to help
Author, year, country		Jones et al., 2007, <sup>48</sup> Scotland	Kwok et al., 2015, <sup>49</sup> Australia	Lambert et al., 2018, <sup>50</sup> Australia	Lambert et al., 2019, <sup>51</sup> Australia and New Zealand

Study design         Starkcholder perceptions           ifth coeline         Read to larify ambiguous or contradictory dist information and adult         Read to larify ambiguous or contradictory dist information and simplify complexity.           and neck         Qualitative study interviews and focus groups.         Patients expected improved nutrition to whedge after senge the desiribution and distary health condition and distary health condition and distary meds.           and neck         Qualitative study using telephone interviews.         Patients identified that the following factors were important to their interviews.           and neck         Qualitative study using telephone interviews.         Patients identified that the following factors were important to their interviews.           and neck         Qualitative study using telephone interviews.         Patients identified that the following factors were important to their interviews.           and neck         Qualitative study using telephone interviews.         Patients identified that the following factors were important to their interviews.           and neck         Qualitative study using telephone interviews.         Patients identified that the following factors were important to their interviews.           and neck         Qualitative study using telephone interviews.         Patients apportant to their interviews.           and neck         Cross-sectional study using telephone interviews.         Patients apportant to their interviews.           in tenter         Cross-sectional s	29
Study design         Stateholder perceptions           Andy design         Stateholder perceptions           Attic collac         Need to clarify ambiguous or and simplify complexity.           Attic collac         Qualitative study interviews and and simplify complexity.           Attic collac         Qualitative study interviews and and simplify complexity.           Attic collac         Qualitative study interviews and and simplify complexity.           Attic collac         Qualitative study using telephone interviews.           And neck         Qualitative study using telephone factors were important to their advays achieved.           And neck         Qualitative study using telephone interviews.           And neck         Qualitative study using telephone factors were important to their advays achieved.           And neck         Qualitative study using telephone interviews.           And neck         Qualitative study using telephone factors were important to their advays achieved.           And neck         Qualitative study using telephone factors were important to their advays achieved.           And neck         Qualitative study using telephone factors were important to their proved.           And neck         Qualitative study using telephone factors were information provided and interviews.           And neck         Qualitative study using telephone factors were interviews.           And neck         Qualitative stu	
Study design       sort       and adult       and adult       and adult       focus groups.       and neck       and neck       Qualitative study using telephone       interviews.       and neck       Qualitative study using telephone       interviews.	(Continues)
<pre>ith coeliac and adult s or and neck and neck in centre renal rapy, n = 164, stimated ttion n. having</pre>	
Participants Participants Patients $\ge 18$ year w disease, $n = 29$ , family members carers, $n = 5$ . Patients with head cancer, $n = 9$ . Patients attending i dialysis unit for replacement the glomerular filtra rate $< 30$ mL/mi	
Study setting Study setting support charity and local support charity and local support charity and local support charity and across Australia. Haemodialysis satellite units, metropolitan city.	
Phenomenon/research questions         patients understand the renal diet       to support adherence.         To identify the preferences for diet       and nutrition-related outcome         and nutrition-related outcome       measures of patients with coeliac         disease and their carers.       and         To explore experiences of head and       and         nock cancer patients with coeliac       and         disease and their carers.       and         To explore experiences of head and       and         nock distrian-delivered health       behaviour intervention based on         motivational interviewing and       cognitive behavioural therapy.         To gain a greater understanding of       what haemodialysis patients want         in their nutrition and dictetic care.       heater care.         To explore and describe the       perspectives of patients with renal	
Author, year, country Madden et al., 2016, <sup>52</sup> United Kingdom Kingdom Australia Australia Australia Australia Australia Australia Australia	

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	Stakeholder perceptions	<ul> <li>→ dictitian 'seen as a friend';</li> <li>→ genuineness;</li> <li>→ understanding of 'my situation';</li> <li>→ appropriate support;</li> <li>→ effective partnership.</li> </ul>	Patients who perceived that dietitians had an unhelpful engagement style identified the five related themes:	<ul> <li>→ patronising tone;</li> <li>→ not listening to 'our needs';</li> <li>→ biochemical agenda;</li> <li>→ instructive advice given;</li> <li>→ 'overbearing' support.</li> </ul>	Dietitians identified that utilising clinical expertise was part of providing a professional service.	Patient opinion of the dictitian's expertise and their value of dictetic input were influential.	Health professionals identified a lack of understanding of the role of the dictitian and dictetic service.	The majority of health professionals viewed dietitians as integral to the healthcare team and more knowledgeable about nutrition.	Patients perceived that nutrition counselling had positive outcomes.	Most participants (63%) reported the information provided by dietitians was helpful, but some
	Study design				Qualitative study using semi- structured interviews.		Qualitative study that was part of a multi-methods observational study using in-depth focus group interviews and purposive sampling.	Descriptive study using telephone interviews.	Descriptive study using telephone interviews.	Qualitative study using semi- structured telephone interviews.
	Participants	received renal advice on more than one occasion from a dictitian, $n = 66$ .			Dietitians who see clients with lifestyle-related chronic diseases (including weight	neutral approaches), $n = 22$ .	Nurses, dictitians, speech pathologists, occupational therapist and pharmacists, $n = 22$ .	Six health profession groups: nutrition support dictitians, clinical dictitians, director of nursing, hospital administrator, chief dictitian and physician, $n = 300$ .	Adult outpatients, $n = 400$ .	Patients >18 years, diagnosed with T2DM, $n = 30$ .
	Study setting				Australia		Acute medical wards, tertiary teaching hospital.	Hospitals across the USA.	Academic medical centres.	Urban and rural diabetes services.
tinued)	Phenomenon/research questions	disease of the dietitian's communication styles.			To explore dietitians' perspectives of how they develop meaningful relationships with clients in the	context of lifestyle-related chronic disease management.	To explore staff awareness, knowledge and perceptions of the nutritional care of older patients.	To determine the image and activities of the clinical dictitian in a hospital setting.	To explore patient's perceptions of the benefits of nutrition counselling.	To explore patient's perspectives on the role of diet in the management of T2DM and experiences with
TABLE 2 (Cont.	Author, year, country				Nagy et al., 2019, <sup>36</sup> Australia		Ross et al., 2011, <sup>37</sup> Australia	Ryan et al., 1988, <sup>38</sup> USA	Schiller et al., 1998, <sup>42</sup> USA	Siopis et al., 2021, <sup>59</sup> Australia

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	ric and not r needs. ong wait hours service barriers to	if the edge as a root of the edge of the e	ople with ant.	errals and or nutrition rrent services DM were	ents to a on the extensive	d to access to ded fees, and intments and to consult	important to	ing and relationships, and that olvement to \$ own health.	(Continues)
Stakeholder perceptions	(25%) found it gene personalised to theii Participants perceived 1 times, lack of out-of options and cost as	Past unpleasant experie demotivated engage dietetic services, but dietitian was perceiv person and a good influenced participa	Dietetic services for pee T2DM were import	There was a lack of ref referral pathways fo services and that cu for people with T21 inadequate.	Preference to refer path dietitian for nutritic management due to training they receive	Referral barriers related dietetic service inclu location of services availability of appo- patients' motivation with a dietitian.	Patient-centred care is patients.	Valued dietitians foster maintaining caring individualised care, enabling patient inv take control of one'	
Study design			Qualitative study using semi- structured telephone	interviews.	Qualitative study using semi- structured telephone interviews.		Qualitative study using individual semi-structured telephone	interviews.	
Participants			Dietitians working in private practice and/or hospital or	community centre and counselling patients with T2DM at least twice a week, $n = 31$ .	Doctors practicing in a discipline relevant to the nutritional management of people with T2DM, and treating patients	with T2DM, $n = 15$ .	Adults ≥18 years who had participated in ≥1 dietetic	consultation; receiving nutrition care for $\ge 1$ medical conditions, $n = 11$ .	
Study setting			Australia		Sydney, Australia		Dietitian-specific primary health	clinics across one state in Australia.	
Phenomenon/research questions			To gain insight into the experiences and perspectives of dietitians who	counsel people with T2DM, with regard to current dietetic services.	To investigate doctors' experiences and opinions of dietetic services for people with T2DM in Australia.		To explore patients' experiences and perspectives of patient-centred	care in individual dietetic consultations.	
Author, year, country			Siopis et al., 2020, <sup>60</sup>	Australia	Siopis et al., 2021, <sup>61</sup> Australia		Sladdin et al., 2018, <sup>62</sup>	Australia	

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Stakeholder perceptions	Patients reported significantly higher scores compared to dietitians for inventory items 'shared decision making', but significantly lower scores for 'providing holistic and individualised care', 'knowing the patient/dietitian' and 'caring patient-dietitian' relationships.	Physicians believed that dietitians involved in prenatal care should be adept in prenatal nutrition and maintain good working relations with patients.	Parents perceived that the skills and attributes of the dietitians in undertaking paediatric weight management as highly important and the client-centred approach in the intervention group produced a positive and supportive environment for families.	Majority of participants rated treatment by a dietitian as very helpful. Participants <52 years old were more likely to report their contact with a dietitian as being unhelpful. Participants reported with much information and advice on diet and nutrition it is hard to know what is correct and who to listen to.	Satisfaction with dietetic consultation via video was high.
Study design	A cross-sectional survey using validated patient and dietitian versions of an inventory to measure patient-centred care in dietetics.	A market research study using semi-structured telephone interviews.	Qualitative study.	A cross-sectional, self- administered survey.	Qualitative study using semi- structured telephone interviews.
Participants	Patients >18 years attending at least one individual dietetic consultation in primary care. Dietitians who self-reported previous or current experience working in primary care, $n = 133$ .	Obstetrics/gynaecology physicians, $n = 130$ .	Principal carers of obese children aged 5–11 years who had participated in an associated study, $n = 17$ .	Adults $\ge 18$ years, diagnosed with or treated for cancer, n = 1073.	Families, $n = 12$ .
Study setting	Dietetian-specific primary health clinics across three states in Australia.	One state, USA	Two major cities, Scotland.	Ireland	Outreach clinics, South- West England.
Phenomenon/research questions	To compare patients and dietitians' perceptions of patient-centred care in dietetic consultations.	To identify physicians' expectations for quality nutrition care delivered in prenatal care.	To explore the thoughts and feelings of parents of children with obesity who had undertaken dietetic consultations either employing behavioural change techniques or delivered by dietitians with no formal training in these techniques.	<ul> <li>To conduct a national survey to determine:</li> <li>1) survivor's experiences in relation to nutrition and dietrelated problems,</li> <li>2) perceived importance of the role of nutrition to cancer survivors,</li> <li>3) the experience of accessing dietetic support,</li> <li>4) the sources where survivors get nutrition information, and</li> <li>5) their use of alternative dietary</li> </ul>	strategies. To explore parent/carer and child perspectives of video consultations
Author, year, country	Sladdin et al., 2019, <sup>63</sup> Australia	Splett et al., 1994, <sup>64</sup> USA	Stewart et al., 2008, <sup>4</sup> Scotland	Sullivan et al., 2020, <sup>65</sup> Ireland	Trace et al., 2020, <sup>66</sup> United Kingdom

country	Phenomenon/research questions	Study setting	Participants	Study design	Stakeholder perceptions
	as an alternative or supplement to existing regional dietetic care.				Parents perceived video consultations improved access to specialised nutrition advice.
					Children preferred video consultations to other forms of dietetic consultations.
Vincze et al., 2018, <sup>67</sup> Australia.	To provide a qualitative insight into women's perspectives of engaging with a dietitian (and exercise physiologist) through video consultations for tailored nutrition and exercise care.	New South Wales.	Women who were 3–12 months post-partum with a BMI $\geq 25$ or >2 kg weight retention from their most recent childbirth, $n = 21$ .	Qualitative design using semi- structured telephone interviews.	Tailored advice from a dietitian (and exercise physiologist) received via video consultations is acceptable for post-partum women and offers a viable alternative to in person care.

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Thirty-four studies used qualitative methods to explore participant experiences. Of the qualitative studies, semi-structured or unstructured interviews were predominantly used, with 29 studies using this as the only method for data collection.<sup>26-30,32,35,36,38,40,42-44,48-51,53,55,56,59-62,64,66-69</sup> Three studies used a combination of qualitative data collection methods using interviews and focus

collection methods using interviews and focus groups.<sup>39,41,52</sup> Two studies used focus groups as the only method of data collection.<sup>31,57</sup>

Eight studies used quantitative methods for investigating patient participant's experiences of nutrition care. All of these studies used surveys asking participants to rate satisfaction with dietetic services using a rating scale.<sup>33,37,42,45–47,54</sup> Four studies used mixed methodologies combining a survey instrument with qualitative methodologies.<sup>34,42,54,63</sup> One study used mixed methodology that included a medical record review, a patient satisfaction survey and semi-structured, in-depth interviews.<sup>42</sup> One used a semi-structured patient satisfaction questionnaire that included a pre-existing survey instrument and open-ended questions.<sup>54</sup> One study combined interviews, focus groups and an online survey.<sup>34</sup> Another cross-sectional study used an inventory to compare patient and dietitian perceptions of patient-centred care in dietetic consultations.<sup>63</sup>

# Quality appraisal

Qualitative studies were found to have clear research questions and used appropriate research methods (refer to Supplementary Information: Table 4 Quality appraisal of studies). Several studies provided limited justification for study design.<sup>26,28–32,57,58</sup> Twelve studies failed to consider, or provide limited discourse about, the relationship between the researcher and participants or the use of reflexivity through the research journey.<sup>26,28–30,34,39,44,49,57,58,64,69</sup> Fourteen qualitative studies reported limited information related to ethical considerations for the research, with only seven of the included studies reporting ethical approval,<sup>31,32,34,40,41,50,52</sup> and two reporting consent to participate.<sup>49,67</sup>

Quantitative study appraisal found that all studies had clearly described participant sampling, study settings, outcomes measures and statistical analysis (refer to Supplementary Information: Table 5 Quality assessment quantitative studies). Five of the eight quantitative studies identified confounding factors, including bias, and strategies to address these factors.<sup>33,46,47,54,63</sup> Studies that used a survey instrument inconsistently documented the validity of the instrument, and little information indicating reliability and utility was provided.<sup>33,34,37,42,45–47,54,63,64</sup> For all other methods used to explore experiences, no information was documented regarding reliability, utility or reflexivity.

# Thematic analysis

Five themes were identified: (1) desire for an individualised approach, (2) accessing dietetic service; (3) perceived impact of nutrition care on the patient; (4) relationships between stakeholders; and (5) holders of nutrition expertise. The desire for an individualised approach to dietetic care was identified by stakeholders in 28 of the eligible studies. There was some overlap found in themes where codes could be categorised to more than one theme. Although some themes included all participant groups, two themes were specific to patients' perspectives and were related to desire for individualised care and the impact of nutrition care on the patient. Table 3 provides a summary of themes identified through analysis.

# Theme 1: desire for an individualised approach

Patients described that they desired their dietetic care to be individualised to their medical condition/s and personal context, <sup>26,28–30,33,36,38,39,41,42,44,46–48,50,52,53,59,62,63,67,69</sup> with 13 studies finding that patients reported this was often not their experience. <sup>26,28,30,41,44,48–50,52,53,59,62,67</sup> The three common areas identified as requiring personalisation were advice and counselling (n = 16), <sup>28,30,36,39,41,42,44,46,48–50,52,53,62,67,68</sup> written information (n = 10)<sup>30,33,38,41,42,44,47,49,52,53</sup> and goal setting (n = 9). <sup>38,41,44,48,52,62,67,69</sup>

Patients expressed their reasons for engaging with a dietitian included a belief that they would be supported with individualised care, <sup>49,50</sup> and not with a 'one-size-fitsall approach'.<sup>62,67</sup> Patients reported to be confused when information provided by dietitians was limited or unspecific, <sup>28,30,49</sup> especially if it did not meet their needs<sup>62</sup> or contradicted their personal beliefs.<sup>36,41</sup> Post-bariatric surgery patients felt that the ideal programme would be one that is patient-specific rather than programme-specific.<sup>26</sup> Similarly, patients with newly diagnosed type 2 diabetes mellitus wanted dietitians to 'sit down and take time, talk, work things out' expressing that, strategies used with previous patients may not work.<sup>30</sup> When experiencing individualised dietetic counselling,

 TABLE 3
 Themes identified from analysis of studies included in a systematic qualitative review exploring stakeholder experiences of dietetic service and care delivery

•		
Themes	Definition/subthemes	Illustrative quotes
Desire for an individualised approach	Patient views on personalised: Advice and counselling Goal setting Written information	<ul> <li>'the ideal program would be one that is patient specific, not program specific<sup>67</sup></li> <li>'be more individualised and try to sit down and take time, talk, work things out. Don't try and fix me the way you fixed the ones before, we are all different<sup>228</sup></li> <li>'they were being recognised as individuals rather than the dietitian assuming their diet was unhealthy because of their weight<sup>542</sup></li> </ul>
Accessing dietetic service	Referrals Location Frequency of contact Reputation of dietitian Aligned with disease trajectory	'If doctors believe in you and they talk to the patient and say "I want you to sit down and talk with the dietitian and it is really important" that makes a big difference <sup>66</sup>
Relationships between stakeholders	Professional relationships Therapeutic partnerships	<ul> <li>'you need to have good relationships with the people you're dealing with you just want somebody that's interested, that's going to be a part of what your journey.<sup>'68</sup></li> <li>'after I was diagnosed, I went to a dietitian and she laid it all out. I wasn't impressed. This woman was just there to purposely lay down a diet, to put me in line and show me this, that, this that<sup>'28</sup></li> <li>'I see it as a partnership for me to get the best results I can'<sup>68</sup></li> </ul>
Dietetic care making an impact	Physical and psychological impacts on the patient	"gained greater confidence in their ability to "take charge of their bodies" and had witnessed outcomes (body composition, weight and general health) that placed them at a different foundation from which they could bring about and sustain future lifestyle changes" <sup>69</sup>
Holders of nutrition expertise	Dietitian as the expert Patient as the expert	<ul> <li>'I would go to a dietitian because food and dietetics is their specialty area. They've been trained<sup>30</sup></li> <li>Nurses 'regarded the dietitian as the expert on nutrition for patients with Total Brain Injury<sup>31</sup></li> <li>'recognized their [patients] unique expertise, they expressed a desire to have input, control and a sense of ownership over decisions made'.<sup>67</sup></li> </ul>

patients generally viewed nutrition care provided as important, positive and helpful.<sup>36,41,42,47,53,62</sup> Patients valued the dietitian's recognition of their culture, life stage, medical, family or economic circumstances and the resulting tailored and practical advice.<sup>28,41,42,52</sup> Having choice and control over changes was also seen as important with patients preferring to be guided towards lifestyle changes,<sup>39</sup> allowing them to set and adapt their own goals or targets.<sup>28,30,39,41,44</sup>

Aspects of individualisation considered essential by patients included their background and history, underlying factors influencing their health and lifestyle choices<sup>62</sup> and guidance about how to realistically prioritise multiple components of the diet.<sup>50,52,67</sup> Patients perceived that goal setting increased motivation, provided encouragement<sup>69</sup> and changed behaviour.<sup>38</sup> Patients preferred written information to contain prescriptive diet plans and practical advice<sup>33,41,50</sup> tailored to their individual learning styles.<sup>41,50</sup> Written information was viewed positively when it helped patients to think more about the food they were eating and changes to their behaviour.<sup>44,50,53</sup> When provided in this format, patients were more likely to recall and refer back to these written resources,<sup>42,44</sup> and report a positive experience of nutrition care.<sup>42</sup>

When care was not individualised patients described being pushed through an impersonal system,<sup>26</sup> dietitians as dictative<sup>62</sup> and feeling disappointed by the lack of personalised and specific written diet plans.<sup>48,49,67</sup> Some patients indicated that these counselling approaches discouraged them from attending follow-up appointments<sup>39</sup> and that written resources contradicted dietetic counselling<sup>46</sup> which did not meet their expectations.<sup>52</sup> Some patients expressed that they had not been asked about their own goals<sup>44</sup> and felt overwhelmed if they needed to make multiple changes to their diets.<sup>52</sup>

Dietitians also recognised the importance of providing individualised care.<sup>34,51,56,60,62</sup> Tailoring dietary advice to the needs of the patient was described as counselling competence<sup>34</sup> with recognition that this essential skill was learned over time through experience in clinical practice.<sup>51</sup> Dietitians supported the need to develop resources better suited to the patient's health literacy levels<sup>51</sup> including meeting the needs of ethnically diverse groups.<sup>51</sup> Dietitians also highlighted that information sourced online by patients was often contradictory, believing this contributed to unnecessary dietary restriction, patient confusion and anxiety.<sup>51</sup>

## Theme 2: accessing dietetic service

Patients and dietitians described factors that influence access to dietetic service including geographical service location, attitudes of referrers and healthcare team to access, preconceptions of patients towards dietitians, the timing of dietetic care delivery, resource and policy

constraints and service delivery modes. Patients identified barriers related to locating and accessing outpatient dietetic services close to their home or workplace,<sup>44,60</sup> and transportation and travel-time issues.<sup>26,28,31</sup> Patients viewed both availability and timing of consultations as important to their health journey,<sup>28,41,44,48,49,52</sup> especially in relation to their medical diagnosis.<sup>28</sup> They felt that the co-location of dietitians with medical specialists or health services<sup>31,33,40</sup> and coordinated and sequential timing of appointments would alleviate barriers related to access to services, transportation and travel time.<sup>40</sup>

Patients reported that frequency of appointments was an important motivating factor for patients to engage with dietetic services<sup>41,44,67</sup> and included consultations of 'sufficient' length.<sup>30,52</sup> Patients waiting for long periods prior to their initial dietetic appointments directed their own learning, mostly online, to be more informed about their condition.<sup>31,52,65</sup> Dietitians also identified physical clinic location and appointment waitlists as reasons that patients did not attend dietetic services.<sup>60</sup>

Both patients and dietitians identified that the value placed on dietetic care by referring practitioners played an influential role in choosing to access dietetic services, with doctors' referrals being particularly motivating.<sup>43,51</sup> Encouraging or ambivalent attitudes towards dietitians influenced the patient's decision to access dietetic service affecting the patient's decision to attend, continue or terminate dietetic courselling.<sup>39,44</sup>

Patients who had access to dietetic care sometimes perceived that this care mismatched their disease trajectory. Patients expected care to relate directly to their medical diagnosis, disease progression and medical treatment plan;<sup>26,28,49,53,67</sup> however, they sometimes viewed their dietetic care as inconsistent during critical stages of their treatment.<sup>26,28,49,53</sup> Patients with head and neck cancer reported that dietitians should be available earlier in their treatment and care sustained post medical treatment.<sup>53</sup> Obstetric patients reported regular dietitian contact enhanced motivation during a postpartum weight loss intervention.<sup>67</sup>

Dietitians reported that resource and policy constraints were barriers to patient access. Such constraints included insufficient government-subsidised sessions for optimal long-term management of chronic conditions,<sup>60</sup> inadequate hours to service the number of patients referred,<sup>60</sup> inadequate dietetic staffing<sup>32,51</sup> and inadequate funding for interpreter services.<sup>51</sup> This was frustrating for dietitians intending to follow best practice guidelines and implement regular dietetic follow-ups for optimal weight and chronic disease management.<sup>60</sup>

Modes of consultation also impacted access, with patients expressing the benefits of telehealth. Postbariatric surgery patients viewed the ability to contact their bariatric team members directly via e-mail or telephone as beneficial.<sup>26</sup> Video consultations with the

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dietitian were preferred for parents of children with chronic kidney disease and for postpartum women in a weight management programme.<sup>67</sup> Video consultations were perceived as convenient, individualised and preferred over standard health professional consultations, and eliminated logistical challenges commonly experienced by families.<sup>66,67</sup> Conversely older patients (mean age = 62 years), attending a haemodialysis unit, were less likely to find telehealth acceptable, with only a quarter stating they would attend such appointments. Barriers included limited access to technology and a lack of confidence in using it.<sup>54</sup>

## Theme 3: relationships between stakeholders

Relationships were identified as important for all stakeholder groups with particular importance placed on the interprofessional relationships between the dietitian and the multidisciplinary team, and the therapeutic partnership between the patient and dietitian.

In primary care settings, dietitians who were part of multidisciplinary teams felt that strong interprofessional relationships resulted in respect for their services and enhanced their ability to provide quality care.<sup>32</sup> Collaborative working relationships improved knowledge of nutrition care for the whole team,<sup>32,40</sup> and increased referrals to dietitians.<sup>40</sup> Patients also viewed integration with the multi-disciplinary team as important for dietetic service,<sup>41,58</sup> valuing dietitians who worked collaboratively.<sup>42</sup>

Patients appreciated dietitian-patient relationships when the dietitian was caring, positive, enthusiastic, supportive, respectful, reassuring and trustworthy,<sup>48,52,53,59,62</sup> describing their connection with their dietitian as being 'instrumental to their healthcare progress'<sup>62</sup> and 'becoming nearly like a friend'.<sup>53</sup> Patients desired to be viewed as 'a person',<sup>30,55</sup> and being listened too<sup>42,48,59,62,67</sup> as this was important to building a therapeutic relationship.<sup>30,44,52,53,62</sup> Other factors considered important in building therapeutic relationships between patients and dietitians included personalised and flexible approaches, frequent consultations<sup>44</sup> of 'sufficient' length<sup>30,52</sup> and seeing the same dietitian at each consultation.<sup>50,52,62</sup>

When patients viewed consultations as a partnership, they saw this an important factor in the effectiveness of care.<sup>41,68</sup> This partnership was valued when advice was adjusted to the changing circumstances of the individual's life.<sup>39</sup> Dietitians also experienced strong therapeutic relationships with patients when they focused on partnership and collaboration,<sup>56</sup> rather than instructional models for providing nutrition advice.<sup>34</sup> Other health professionals expressed that the patient–dietitian relationship was important for motivation, compliance and improvement in patient outcomes.<sup>64</sup>

Some patients expressed disappointment with dietitians and reported challenges in forming relationships when they perceived dietitians to have a controlling, directive approach or a pre-set agenda for consultations.<sup>30,62</sup> Patients described this approach as 'belittling'<sup>55</sup> and 'nagging'.<sup>36</sup> Dietitians were described by some patients as health professionals who 'punish' individuals through restrictive eating and negative counselling styles. A study exploring patient engagement experiences with renal dietitians found that patients reported 'hiding in the bathroom and pretending to be asleep' to avoid dietetic consultations.<sup>55</sup> Patients who had previous negative experiences with a dietitian reported that this discouraged future engagement with dietetic care.

Patients and dietitians describe empathy,<sup>34,42,54–56,62,69</sup> honesty and trust<sup>39,41,56,62</sup> as important to an effective therapeutic relationship. Patients found it comforting when the dietitian appeared accepting of their struggles to follow dietary advice.<sup>55</sup> Some patients doubted dietitians' capacity to build true empathy if they had not experienced the same medical condition themselves,<sup>41,53</sup> particularly for overweight patients.<sup>53</sup> Dietitians asserted they actively strive to be empathetic<sup>34,56</sup> acknowledging the feelings patients may be experiencing,<sup>41,56</sup> and aware that some patients cope better than others.<sup>34,41</sup>

Communication was viewed as important with patients reporting that essential capabilities were interpersonal skills, nonverbal communication, professional values and counselling skills.<sup>34</sup> Patients reported that good communication skills and the ability to create rapport were essential skills for individualising care.<sup>41,62</sup> Initial interactions were important, and patients suggested that personal appearance and manner may negatively affect communication and relationships. Patients felt that dietitians who were overdressed, for example wearing a suit, jewellery and high heels, might be 'overbearing' or 'threatening' with their communication,<sup>34,55</sup> or a dietitian's unpleasant or surly manner<sup>41</sup> would decrease patient engagement.

## Theme 4: dietetic care making an impact

Patients described that dietetic care had both physical and psychological impacts on their lives, with the act of seeing a dietitian reported to improve accountability,<sup>62</sup> demonstrating the positive impact of individualisation, access and effective relationships. When the dietitian was seen as supportive and trustworthy, and positive feedback was provided, patients' motivation for making dietary and behaviour changes increased.<sup>41,49,62</sup> Dietetic care was perceived by patients to improve nutrition knowledge, empowering them to make healthy choices and informed decisions by understanding appropriate portion sizes, nutritional content and ideal foods to eat.<sup>30</sup> Goal setting assisted with making behaviour changes,<sup>38</sup> and positive health-related changes such as body composition and weight loss were seen<sup>41,67,68</sup> as a result of nutrition care. When this occurred patient's feelings of self-esteem, motivation, confidence and control over their situation increased.<sup>28,41,44,62,67,68</sup>

In contrast, negative impacts of dietetic care were described as patients feeling guilt and frustration when they were unable to maintain behavioural or dietary changes or achieve expected outcomes such as weight loss.<sup>41</sup> Patients described fear and anxiety when nutrition advice was linked to dire health outcomes, such as 'needing to eat to survive',<sup>28,53</sup> but this link also empowered them to take control.<sup>53</sup> Fear was associated with consuming or serving the 'wrong' food for patients with renal disease<sup>50</sup> and making dietary changes was seen as 'scary'.<sup>41</sup>

## Theme 5: holders of nutrition expertise

There were differing opinions of patients, dietitians and other health professionals on who was the nutrition expert and the impact this had on the experience of dietetic service delivery. Patients perceived dietitians as the experts in food and nutrition across primary care, ambulatory<sup>67</sup> and hospital settings<sup>39</sup> and believed that dietitians have a strong knowledge base due to training in the field<sup>29,39,67</sup> providing science-based advice.<sup>67</sup> Expertise in medical conditions, such as coeliac disease<sup>52</sup> and obesity,<sup>27</sup> was identified as being important. The formal process of being referred to a 'professional' prompted patients to make dietary changes,<sup>44</sup> with the dietitian valued as a competent expert.<sup>53</sup>

Some patients had misconceptions about dietitians<sup>41,69</sup> reporting that they did not understand the dietetic role.<sup>29,30,39,44</sup> Patient expectations of dietitians were influenced by media representation and experiences in health food stores.<sup>41,65</sup> There was a lack of understanding about benefits of receiving support from a dietitian.<sup>30</sup> Dietitians were seen as helpful and informative and assisted the patients in understanding their diet, but lacked professional visibility.<sup>37</sup> Patients expressed surprise about the dietitian's actual approach and relief that the focus was on a balanced and healthy diet rather than their preconceptions of a restrictive approach to nutrition care.<sup>44</sup> Perceptions often changed after dietetic consultations.

Further patients were often unsure who led nutrition care,<sup>28</sup> or if they had seen a dietitian during their care.<sup>36</sup> Several patient groups described wanting to receive their nutrition care from health professionals other than dietitians such as doctors and nurses.<sup>29,54</sup> In primary care, general practitioners were regarded as the preferred providers of nutrition care because they were able to take a patient's medical history into consideration.<sup>29</sup> Patients reported that dietitians were not the only source of information and advice they encountered regarding nutrition and described feeling frustrated, anxious and confused about receiving conflicting diet advice from many sources including other health practitioners,<sup>52</sup>

often leaving them with more questions than answers. $^{50,52}$  Other patients found it reassuring if more than one healthcare professional confirmed the same information. $^{41}$ 

Patients also perceived themselves as experts, expressing their ability to offer unique knowledge and insights into dietetic consultations as a result of their personal experience.<sup>56,62</sup> However, when dietitians controlled the encounter, patients felt disengaged.<sup>62</sup> Patients emphasised the importance of dietitians listening, and acknowledging the potential contribution the patient's own personal expertise could make to the consultation, respecting the patient's experience of their own lives.<sup>56,62</sup>

Medical and nursing practitioners in the intensive care setting believed nutrition care was the responsibility of nurses.<sup>35</sup> However, they asserted that a multidisciplinary approach, which included dietitians, was needed when making nutrition care decisions.<sup>35</sup> Nurses indicated they were more likely to speak directly to medical officers about malnourished patients,<sup>57</sup> whereas allied health staff indicated ward-based nutrition activities were mainly the responsibility of nurses.<sup>57</sup>

Other studies found that health professionals viewed dietitians as experts in nutrition<sup>27,31,35,40,43,58,61</sup> and an important resource for patient care, nutritional guidance and education.<sup>27,35,43,58,61</sup> Nursing and healthcare leaders described dietitians as competent, knowledgeable professionals integral to the healthcare team.<sup>35,43,58</sup> When the dietitian was co-located with a community mental health service, the multidisciplinary team reported they valued collaborative and informal discussions with the dietitian which enabled clinicians to 'expand their skill base'.<sup>40</sup> Dietetic specialisation was highly regarded, with primary care providers preferring to refer patients to a specialty dietetic service for nutrition care.<sup>27,31</sup>

Dietitians identified themselves as the nutrition experts, especially in optimal management of diabetes,<sup>60</sup> malnutrition<sup>57</sup> and nutrition support,<sup>58</sup> and viewed dietary advice from other health professionals as a potential barrier to patient empowerment, especially when advice was inaccurate.<sup>51</sup> Dietitians also reported that they valued the opinions of both patients and the multidisciplinary team.<sup>56</sup>

# DISCUSSION

This is the first systematic review, to the authors' knowledge, that explores the published literature and describes the experience and views of multiple stake-holders on dietetic service delivery. In the 44 included studies, five themes were identified: individualised care, access to dietetic service, impact of nutrition care on patients, relationships between stakeholders and holders of nutrition expertise.

In this review, stakeholder perceptions of nutrition care delivery varied, with dietitians sometimes viewing

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their care provision more highly than what patients perceived. Across many settings, patients reported receiving nutrition care that did not meet expectation or need. This finding is similar to other studies exploring patient's perceptions of health care where healthcare professionals rating of care delivery is significantly different to patients.<sup>70,71</sup> This can be attributed to differing values between health professionals and patients about what aspects of care are important, and that different methods are used to explore perceptions of care, and definitions of quality of care.<sup>70,71</sup> This notable difference in perceptions supports the need for targeted training of health professionals in patient-centred approaches, including dietitians<sup>72</sup> to positively impact patient experiences with dietetic care.

This review identified that patients desired personalised dietetic care; however, this was not often their experience. As individualised care is fundamental to patient-centred care, dietitians may need to examine their understanding of personalised nutrition advice and ensure interpersonal skills are empathetic and responsive to patients' needs.<sup>73-75</sup> Health professional empathy, including in dietitians, has been shown to decline over time<sup>74,76</sup> and, although dietitians strove to be empathic communicators, patient expectations were not always met. Patients described three specific areas for personalisation that have implications for dietetic practice. An understanding of the interviewing, communication and interpersonal skills along with the ability to translate nutrition science will ensure that dietitians as nutrition experts met patient expectations. The Nutrition Care Process (NCP) model is used by dietitians internationally to systematically guide nutrition care across all practice settings and emphasises the importance of client-centred care.<sup>77</sup> The NCP consists of four separate but interconnected steps: Nutrition Assessment and Reassessment, Nutrition Diagnosis, Nutrition Intervention and Nutrition Monitoring and Evaluation. The NCP model influences both national dietetic association competency standards for professional practice and the curriculum of dietetic courses. Only step three of this model, Nutrition Intervention, outlines the patient's role in that the patient and dietitian jointly determine goals; however, the process is dietitian-led with intervention goals based on the nutrition diagnosis and nutrition prescription.<sup>77</sup> To improve patient engagement in nutrition care, patient input is needed from the first step of the NCP process, Nutrition Assessment; dietitians need to ensure they allow time to explore what the patient needs, set goals with, not for, the patient and provide tailored written advice specific to their patient's needs and goals.

This review found many stakeholders, including patients, viewed dietitians as nutrition experts; however, patients frequently preferred doctors to provide nutrition care, consistent with the literature.<sup>78–82</sup> Positioning dietitians as experts in nutrition care requires strong

engagement and endorsement by medical practitioners and other health professionals.<sup>60,83</sup> Development of supportive professional relationships and simplifying referral pathways may improve patients' motivation to access dietetic care. Patients report their own expertise regarding their health also needs to be acknowledged in dietetic service provision. This is consistent with the patient-centred care principle of shared decision making where valuing the patient's perspective, and personalising care, can result in improved adherence to treatment, accountability and engagement in care.<sup>84</sup>

The Internet has allowed near-universal access to nutrition information, and nutrition advice decreasingly exists solely within formal dietetic service contexts. Consistent with our review, access to health care has been identified as one of the most important patient perceptions of quality of care.<sup>84</sup> This review identified that patients often utilised online resources, particularly when dietetic service access was delayed.<sup>52</sup> Dietitians need to be aware of this and actively flag or 'signpost' sources of good-quality online information.<sup>50,51</sup> Internet sources of nutrition information are often misleading and inconsistent,<sup>85</sup> and this review found that dietitians were unlikely to steer patients in this direction. As an underrepresented voice in the digital space,<sup>86</sup> opportunities exist for dietitians to work with patients to informatively discover credible food and nutritionrelated information in the online environment. The challenge for dietitians is to determine how to translate emerging nutrition science into simple language and practical online advice that resonates on an individual level,<sup>85</sup> and to be able to direct patients to credible online information where they can further their own learning.

Despite the decades-long presence and availability of telehealth models for care delivery, global growth and use had been much slower than expected in health care.<sup>87</sup> As a result of infection control measures during the COVID-19 pandemic in 2020, telehealth models of care have been rapidly adopted, creating opportunities to meet patient expectations of service delivery.<sup>87</sup> This review identified that, prior to the pandemic, nutrition care had mostly been limited to traditional models of face-to-face service delivery. Current and future models of nutrition care can leverage off this telehealth revolution to reimagine and redesign dietetic services, and to train the future dietetic workforce to optimally utilise technology to eliminate access barriers to nutrition care.

## STRENGTHS AND LIMITATIONS

This review included a wide variety of studies in terms of study population, setting and health conditions, with the review methodology inclusion of a broader range of articles than may otherwise not be included. With studies across 50 years, there was significant growth in publications focused on qualitative experiences, reflecting changing interests and views of stakeholders. Limitations included articles in English only, restricting the cultural perspectives represented. In addition, all studies were from English-speaking OECD countries, with the exception of Israel, limiting the representation of different healthcare contexts. There were varying degrees of quality in the studies included and although no studies were excluded based on quality appraisal, numerous studies did not account for potential bias where dietitians appeared to deliver care in the research setting or researchers did not declare reflexivity. The type of synthesis employed was suitable for the review of heterogeneous evidence, and consideration of the best available evidence for patient care delivery aided assessment of risk of bias.<sup>88</sup>

# Implications for clinical practice and future research

This novel review furthers our understanding of how dietetic care is valued by patients and other stakeholders, emphasising the need for dietitians to prioritise personalised nutrition care to meet patient expectations. Our current dietetic workforce needs to consider ways to practice empathy, engage in positive therapeutic partnerships and acknowledge the patient as an expert in their own life. Seeking patient experiences when designing and delivering dietetic training programmes will help ensure emerging dietitians have the skills required to effectively seek and meet patients' needs. Further investigation and exploration of stakeholder experiences of dietetic service to inform the design of dietetic services that result in change to dietetic practice, service delivery, which engages patients in positive and supportive partnerships is needed. Acknowledging and embracing the flexible approaches to delivery of care, including telehealth, social media and the Internet, may help meet patients' preferences for access to dietetic services.

## **AUTHOR CONTRIBUTIONS**

Andrea Elliott designed the review, did the literature search, extracted and interpreted the data, drafted and critically revised the manuscript.Simone Gibson designed the review, interpreted the data, wrote original content and critically revised the manuscript.

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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. The reporting of this work is compliant with PRISMA<sup>18</sup> and ENTREQ<sup>19</sup> 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 registration no. CRD42019129171. 2019) have been explained.

### PEER REVIEW

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# SUPPORTING INFORMATION

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