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Potential use of Anthropometric Parameters to Predict the Anemia Status of Adolescent Girls

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ABSTRACT

The study assesses the potential use of anthropometric parameters and their optimal cut-off value for predicting the anemia status of adolescent girls. This cross-sectional study analyzed data from 2,184 adolescent girls aged 15–19 years from West Bandung and Sumedang districts of Indonesia who participated in the Better Investment for Stunting Alleviation Program (BISA). Anemia is defined as a Haemoglobin (Hb) level <12 g/dl and was analyzed by HemoCue® 201+. Anthropometric parameters studied were Body Weight (BW), BMI-for-Age z-Score (BAZ), Waist Circumference (WC), Waist-to-Hip Ratio (WHR), and Waist-to-Height Ratio (WHtR) and all were measured according to WHO procedure. Receiver Operating Characteristics (ROC) was used to analyze the potential of anthropometric parameter to predict anemia status. Based on multivariate analysis, a significant correlation was found between age (OR=0.88; 95% CI:0.79–0.97) and WHtR (OR=0.12; 95% CI:0.02–0.63) with anemia status. The ROC analysis revealed that the WHtR parameter had the highest Area Under the Curve (AUC) for predicting anemia, although with a very low accuracy (AUC=0.529). The optimal cut-off with value of WHtR for adolescent girls was ≤0.44. This study suggests that WHtR is a potential parameter for early detection of anemia status among adolescent girls and needs to be confirmed with further studies.

Keywords: adolescent girls' anemia, anthropometry, Hb, ROC, WHtR

INTRODUCTION

Globally, the number of reproductive women who experience anemia tends to increase from 2010 to 2019. According to World Health Organization (WHO), in 2019 three out of ten women of reproductive age in the world experience anemia. This number was equivalent to 500 million women aged 15–49 years (WHO 2021). The incidence of anemia in Indonesia was getting worse, anemia prevalence in women aged 15–49 years almost doubled from 2013 to 2018 (Ministry of Health Republic of Indonesia (MoH RI 2013; 2018)). According to 2018 Indonesia Basic Health Research, the prevalence of anemia among adolescents aged 5–15 and 15–24 years was 26.8% and 32%, respectively (MoH RI 2018). It made anemia in adolescents as a moderate public health problem in Indonesia (WHO 2010). Adolescent girls were considered to have a higher risk of anemia because their nutritional requirements increased along with rapid growth, menstruation, and future pregnancies (WHO 2011a; Teji *et al.* 2016). According to cross-sectional studies conducted in West Java, the prevalence of anemia among adolescent girls ranged from 14.3% to 45.5% (Sari *et al.* 2022; Agustina *et al.* 2021). As per WHO, anemia in adolescent girls was described by a Hemoglobin (Hb) level less than 12 g/dl (WHO 2011b).

Anemia was a condition caused by multideterminant, which were biological determinants such as malnutrition, growth, gender, physiological state, age, and ethnicity; infection and inflammation determinant; genetic Hb disorder; social and environmental determinants (WHO 2020). Iron deficiency remained a prominent cause of anemia worldwide (WHO 2021). Many studies have been conducted to analyze the interrelation between nutritional status and anemia status or Hb level. Several studies reported positive correlation between obesity with anemia (Choma *et al.* 2015; Jeong *et al.* 2022), other studies reported the opposite result that obesity is a protective factor against anemia (Huang *et al.* 2015; Gokhale *et al.* 2022)

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and even no correlation (Crivelli *et al.* 2018; Mehdad *et al.* 2022). Although earlier studies reported a correlation between nutritional status and Hb levels in adolescent girls, most of these studies just focus on using Body Mass Index (BMI) as a parameter of antropometry.

Recent studies suggests that anthropometric measures such as Waist Circumference (WC), Waist-to-Hip Ratio (WHR), and Waist-to-Height Ratio (WHtR) can be used to predict Hb level (Dutta *et al.* 2021; Lee & Kim 2016). A cross-sectional study among Malaysian young adults showed that BMI was the best anthropometry parameter for predicting anemia than WC, WHR, and WHtR based on the ROC analysis (Dutta *et al.* 2021). Another study conducted on elderly Koreans showed that weight and BMI as the best predictor of Hb level (Lee & Kim 2016). Thus, previous studies provide the possibility of using anthropometric parameters for the early detection of anemia in a practical, inexpensive, and non-invasive way. To the best of the author's knowledge, this is the first study in Indonesia that uses anthropometric parameters to predict anemia in adolescents. Therefore, our study aims to analyze the accuracy of anthropometric parameters as predictors of anemia status as well as determine the optimal thresholds

METHODS

Design, location, and time

This cross-sectional study uses secondary data from the Nutrition International (NI) funded project, i.e., a baseline survey of the Better Investment for Stunting Alleviation (BISA) Program in West Bandung and Sumedang districts, West Java, Indonesia. The baseline survey was conducted from December 2019 to April 2020. The ethical clearance was obtained from the Research Ethics Committee of the Faculty of Medicine of Padjajaran University (Ethic number: 145/UN6.KEP/EC/2020).

Sampling

The BISA survey used a two-stage cluster sampling. Initially, 30 high schools from each district were selected with Probability Proportion-to-Size (PPS) methodology. The adolescent girls within every high school were selected with systematic random sampling from the list provided by the school, with minimum sample size of each school in West Bandung district of 63 and 61 for Sumedang district of West Java. From the 3,668 adolescent girls who participated in the baseline survey, we analyze a total of 2,184 adolescent girls who have met the inclusion criteria that were student from the high school in West Bandung and Sumedang district, aged 15-19 years, had complete data regarding weight, height, waist circumference, hip circumference, and hemoglobin measurement results.

Data collection

Body weight was measured twice using GEA digital weight scales, with adolescent girls being barefoot and in minimal clothing. The weight measurement was in kilograms (kg) to near 0.1 kg. Microtoise was used to measure height, with adolescent females' feet, heels, buttocks, and shoulder blades put against the stick and head positioned in the Frankfurt horizontal plane. The adolescent girls were measured twice for waist and hip circumference using anthropometric tape while standing straight and relaxed with arms at their sides and feet close together. Waist circumference was measured halfway between the bottom of the rib cage and the top of the iliac crest. The hip circumference was measured at its broadest point (WHO 1995). The measurements were taken in centimetres (cm) and were taken to the closest 0.1 cm.

The ratio of the waist-to-hip circumference was thcn calculated as WHR while the ratio of waist circumference to height as WHtR. BMI-for-Age Z-Score (BAZ) was calculated using WHO AnthroPlus after entrying age, sex, weight, and height data. The Hb levels was measured using capillary fingerpick blood by a HemoCue® 201+ portable device. The Hb value of <12 g/dl was classified as anemia according to the WHO criteria. The Hb value was also adjusted using the recommended altitude adjustment (WHO 2011b). Questions regarding age was collected with self-administrated questionnaire method

Data analysis

A 95% confidence level was used in the statistical analysis. We used SPSS version 22.0 dan MedCalc version 20.218 for data analysis. A normality test was performed using Kolmogorov Smirnov. Frequency, median, minimal, and maximal were presented for not normally distributed data. The Mann-Whitney

test was used to compare the median differences between the anemic and non-anemic groups in each variable. Spearman correlation was carried out to investigate the correlation between age and anthropometric parameters with Hb level. A multivariate binomial logistic regression model was performed to identify the variables that have a significant correlation with the anemia status, with the anemia code as 1 and the non-anemia code as 0.

Body weight, BAZ, WC, WHR, and WHtR data were used as continuous variables, and anemia status was used as a categorical variable in a Receiver Operator Characteristic (ROC) analysis. The ROC and Area Under the Curve (AUC) were calculated by plotting the true positive rate (sensitivity) in the false positive rate (100-specificity) for various parameter cut-off points. The Youden index (J) was used to determine optimal cut-off values for anthropometric measures for detecting anemia. The Youden index was defined as:

$$J = max_c \left(Sensitivity_c + Specificity_c - 1\right)$$

where c was a variable that could take any value (Kallner 2018). The $p<0.05$ was considered statistically significant for all evaluations.

RESULTS AND DISCUSSION

A total number of 2,184 adolescent girls from 35 high schools in West Bandung and Sumedang District were analyzed in this study. The range of an age was 15 to 19 years, and the average was 17±0.9 years old (Table 1). About 40% of adolescent girls aged 17 years old. Anemia was experienced by almost half (49.3%) of adolescent girls, which about 55% among them having mild anemia (Hb:10–10.9 g/dl), 42% having moderate anemia (Hb:8–10.9 g/dl), and 3% having severe anemia (Hb<8 g/dl). It makes anemia in adolescent girls in West Java and Sumedang districts a severe public health problem according to WHO criteria (WHO 2010). A previous study has shown the same results, where about 45.5% of adolescent girls who attended school in Cimahi, Purwakarta, and West Bandung districts in West Java Province had anemia (Agustina *et al.* 2021).

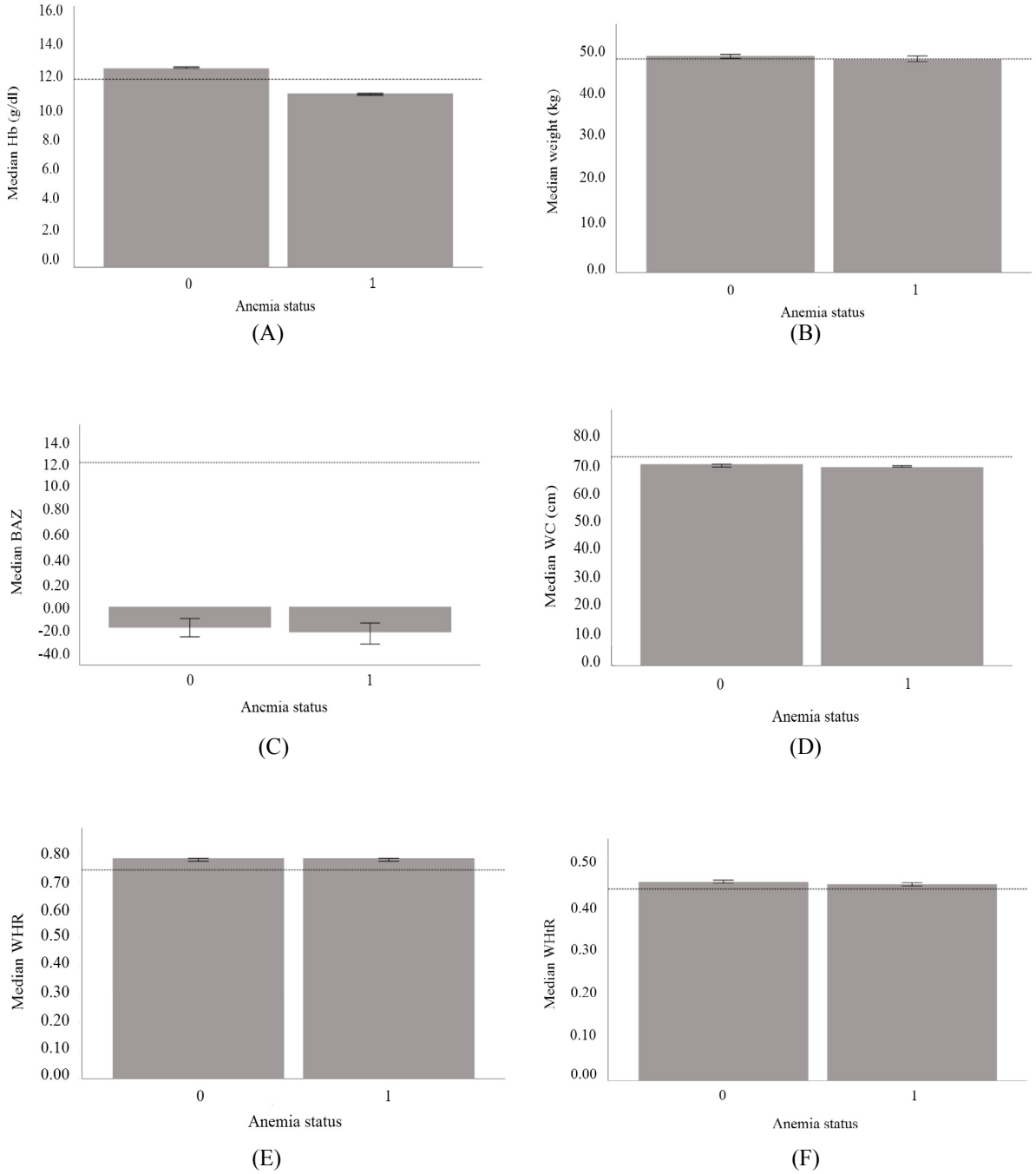
The Mann-Whitney test was used to examine the difference in the values of each variable between the anemic and non-anemic groups. The test was carried out at 95% confidence intervals, with significance considered when $p<0.05$. Among the 2,184 adolescent girls, it was divided into 1,077 (49.3%) of adolescent girls belonged to the anemia group and 1,107 (50.7%) belonging to the non-anemic group. Differences in Hb levels and anthropometric parameters between anemic and non-anemic groups are showed in Figure 1.

Figure 1 showed that the median of Hb levels in the anemia group was 11.1 g/dl (5.7–11.9 g/dl) while the non-anemic group was 12.7 g/dl (12.0–16.3 g/dl), and only WHtR parameter that significantly different between

Table 1. Age, hemoglobin, and anthropometric parameters of adolescent girls

Variables	Median	Minimum–Maximum
Age (years)	17.0	15.0–19.0
Hb (g/dl)	12.0	5.7–16.3
Body weight (kg)	48.0	27.2–104.6
Body height (cm)	153.1	131.0–197.5
Waist circumference (cm)	69.0	46.0–113.5
Waist-to-hip ratio	0.78	0.11–1.74
Waist-to-height ratio	0.45	0.32–0.75
BMI-for-age z-score	-0.21	-3.81–4.70

BMI: Body Mass Index; Hb: Haemoglobin



(A): Haemoglobin (Hb) level (g/dl); (B): Weight (kg); (C): BMI-for-Age z-Score (BAZ); (D): Waist Circumference (WC) (cm); (E): Waist-to-Hip Ratio (WHR); (F): Waist-to-Height Ratio (WHtR)
(0): Non-anemic group; (1): Anemic group
Statistically significant difference ($p<0.05$) was recorded for Hb level (A) and WHtR (F) using Mann-Whitney test
The dotted horizontal line indicating cut-off values
The cut-off for Hb level was 12 g/dl based on WHO reference (WHO 2011b)
The cut-off for weight, BAZ, WC, WHR, and WHtR based on ROC analysis in Table 3

Figure 1. Comparison of Hb levels and anthropometric parameters between adolescent girls with anemia and without anemia

the anemic and non-anemic groups (p=0.018). Other anthropometric parameters, such as BAZ (p=0.127), body weight (p=0.316), WC (p=0.075), and WHR (p=0.167), did not indicate a significant difference between the anemic and non-anemic groups in the Mann-Whitney tests. These results were different from studies in the adult group in Malaysia, which showed BMI, WC, WHR, and WHtR in the anemia group were significantly lower than in the non-anemic group (Dutta *et al.* 2021). The waist-to-height ratio was used as an indicator to measure excess fat in visceral adipose tissue, as well as to determine central obesity in adolescent girls (Browning *et al.* 2010). Research related to WHtR and Hb levels in adolescents is still limited. A study on adult women (>20 years) in China showed that women who are centrally obese tend to have higher Hb levels than those who are not centrally obese (Qin *et al.* 2013).

The bivariate analysis showed there was a positive correlation between age, WC, and WHtR with Hb level (p<0.05). Multivariate binomial logistic regression analysis showed that age (OR=0.88; 95% CI:0.79–0.97) and WHtR (OR=0.12; 95% CI:0.02–0.63) have a significant correlation with anemia (Table 2). It indicated that adolescent girls who were older and had higher WHtR were less likely to have anemia.

Younger adolescent girls tend to be anemic is in line with the study in South Ethiopia, which shows that in the early adolescent period (age 10–13 years), the risk of experiencing anemia was five times higher than in the late adolescent period (age 17–19 years) (Shaka & Wondimagegne 2018). Increasing Hb levels in older adolescent girls were probably influenced by the timing of the growth spurt in adolescents (Jorgensen *et al.* 2019). In addition, the increase in Hb levels along with increasing age may also be affected by an increase in the Mean Volume of Erythrocytes (MCV) and the Mean Mass of Hb in the one Erythrocyte (MCH) with the peak at age 18. Additionally, the Mean Concentration of Hb in the Erythrocyte (MCHC) tends to increase with age in adolescents (Gligoroska *et al.* 2019). Different findings were found in longitudinal studies of Malaysian adolescents, who indicated that the frequency of insufficient iron consumption increased twofold from 13 to 15 years old. This pattern continued until they were 17 years old. Followed by the anemia prevalence almost doubled in the same period (13 to 15 years old) (Krishnan *et al.* 2021)

Adolescent girls with higher WHtR tend not to experience anemia, possibly influenced by increased body fat. The WHtR was known to correlate with visceral fat (Browning 2010). A systematic review and meta-analysis of studies in children and adolescents (4.9–19 years) found that BMI and WHtR were strongly related to body fat evaluated using Dual-Energy X-Ray

Table 2. Correlation between age, anthropometric parameters and Hb level with anemia status

Correlation with Hb level[a]			Correlation with anemia status[b]				
Variables	r	*p*	Variables	B	*p*	OR	95% CI for OR
Age[c]	0.08	0.000*	Model 1:				
Weight[d]	0.02	0.456	Age	-0.14	0.007*	0.87	0.79–0.97
BAZ	0.02	0.258	Constant	3.27	0.003*	26.32	
WC[e]	0.05	0.012*	Model 2:				
WHR	0.04	0.090	Age	-0.13	0.007*	0.88	0.79–0.97
WHtR	0.07	0.002*	WHtR	-2.16	0.013*	0.12	0.02–0.63
			Constant	3.24	0.001*	25.48	

*p<0.05

[a]: Bivariate analysis using Spearman test; [b]: Multivariate analysis using Binomial Logistic Regression Stepwise method

[c]: Years; [d]: Kilogram (Kg); [e]: Centimeter (Cm)

BAZ: BMI-for-Age z-Score; WC: Waist Circumference; WHR: Waist-to-Hip Ratio; WHtR: Waist-to-Height Ratio

OR: Odds Ratio; CI: Confidence Interval; Hb: Haemoglobin

Absorptiometry (DEXA) (Martin-Calvo *et al.* 2016). Studies in adults using five anthropometric indicators, which include BMI, WC, WHR, WHtR, and Waist/Height Circumference 0.5 (WHT.5R), showed that WHtR was the best predictor for body and Visceral Fat Percent Adipose Tissue (VAT) as measured using DEXA (Swainson *et al.* 2017). This study supported the results of Ashwell *et al.* (2012), who suggested using the WHtR indicator instead of BMI and waist circumference in determining obesity when DEXA was unavailable. Studies on adolescents in Taiwan showed there was an increase in Hb levels in adolescents who were obese (Huang *et al.* 2015). Choma *et al.* (2015) also showed an increased Hb and CRP levels in the group with central obesity. An increase in Hb levels possibly due to increased erythropoiesis which occurs along with increasing the body size. However, inflammation in the central obesity, which was indicated by higher CRP levels, was known to be associated with iron deficiency characterized by decreased serum iron levels (Choma *et al.* 2015).

The ROC curves analysis in Table 3 showed that only the WHtR parameter could differentiate (p=0.018) between anemic and non-anemic adolescent girls based on their Hb levels. Although the WHtR could distinguish two groups, its accuracy was very low because the AUC value was 0.5–0.7 (Akobeng 2007) with an AUC (95% CI) value of 0.529. It indicated that WHtR had the potential as a predictor of anemia status for adolescent girls. Future research is needed to analyze the potential of WHtR as a predictor of anemia status in adolescents. The optimal cut-off of WHtR for predicting anemia based on the Youden index was ≤0.44 (Se=45.6%; Sp=60.2%). In predicting anemia, a paired assessment of all anthropometric measures revealed no significant differences (p >0.05). It indicated that the WHtR was not distinctly different from other parameters in detecting anemia in adolescent girls.

The results of this study indicated that the WHtR parameter as a potential predictor of anemia status in adolescent girls had the highest AUC value among other anthropometric

Table 3. Comparison of ROC curves of anthropometric parameters in predicting anemia status of adolescent girls

Variables	AUC (95% CI)	*p*	Cut-off value	Se (%)	Sp (%)	Pairwise comparison of ROC curves		
						Variables	AUC difference	*p*
BAZ	0.519	0.127	≤1.23	91.7	12.6	BAZ~WC	0.003	0.744
						BAZ~WHR	0.003	0.856
BW[b]	0.512	0.316	≤47.7	50.7	53.8	BAZ~BW	0.006	0.283
						BAZ~WHtR	0.010	0.274
WC[c]	0.522	0.075	≤72.5	70.6	35.0	BW~WC	0.010	0.308
						BW~WHR	0.004	0.811
WHR	0.516	0.191	≤0.74	22.8	78.0	BW~WHtR	0.017	0.144
						WC~WHR	0.006	0.554
WHtR	0.529	0.018[a]	≤0.44	45.6	60.2	WC~WHtR	0.007	0.111
						WHR~WHtR	0.013	0.175

[a]p<0.05; [b]: Kilogram (Kg); [c]: Centimeter (Cm)

BAZ: BMI-for-Age Z-Score; BW: Body Weight; WC: Waist Circumference; WHR: Waist-to-Hip Ratio

WHtR: Waist-to-Height Ratio; AUC: Area Under Curve; Se: Sensitivity; Sp: Specificity; AUC: Area Under the Curve

CI: Confidence Interval; ROC: Receiver Operating Characteristics

parameters. As the authors' knowledge, this was the first study on Indonesian that uses the WHtR to predict anemia, so study related to WHtR and Hb levels in adolescent girls was still limited. Based on the ROC analysis, WHtR ≤0.44 was the optimal cut-off for predicting anemia in adolescent girls (Table 3). Previous studies in Malaysian young adults (Dutta *et al.* 2021) showed that BMI was the best predictor of anemia. The order of anthropometric parameters among Malaysian young adults from highest to lowest AUC value was BMI>BW>WC>WHtR>WHR. Although BMI was the best predictor of anemia, the WHtR parameter can be used as a predictor of anemia in young adult women with an optimal cut-off of 0.45 (AUC 95% CI:0.764; Se=83.6%; Sp= 59.1%) (Dutta *et al.* 2021). WHtR as a predictor of anemia was showed in a study conducted on school age children (ages 7, 9, 12, and 14 years) in Shandong, China. In school-age children, both boys and girls with a WHtR 0.30–0.34 and a WHtR≥0.60 had a higher prevalence of anemia than school-age children with other WHtR values (Zhang *et al.* 2021). A study on Korean elderly women showed that the AUC value for WHtR in predicting anemia was 0.52 (Lee & Kim 2016), like our study.

In contrast to previous studies, namely in young adults (Dutta *et al.* 2021) and the elderly (Lee & Kim 2016), BMI was not significantly related to Hb levels, nor was it a predictor of anemia in this study. WHtR has been reported as a parameter, that had potential for an alternative predictor of anemia in adolescent girls. It may be due to previous studies in adults and the elderly where there were significant differences in the parameters of body weight, BMI, WC, WHR, and WHtR (Dutta *et al.* 2021; Lee & Kim 2016). Meanwhile, our study reported significant differences were only found in WHtR parameters between the anemia and non-anemic groups. Some studies reported the WHtR as the best parameter to define obesity (Bacopoulou *et al.* 2015; Bojanic *et al.* 2020). Yan *et al.* (2007) also showed that WHtR had better accuracy than waist circumference-defined central obesity. It was due to the WHtR combining the advantages of BAZ and WHR parameters, which not only considered height in their measurements but also abdominal obesity into account (Yan *et al.* 2007). A study on adolescents in Central Java of Indonesia reported that WHtR had better accuracy than WC as a predictor of excess adiposity (Mulyasari & Pontang 2018). In addition, the almost balanced proportion between the anemia and non-anemic groups in this study might also have caused the accuracy of WHtR as a predictor of anemia in adolescent girls compared to WHtR's accuracy as a predictor in young adults, whose proportion of anemia is around 20% (Dutta *et al.* 2021).

Our study had various strengths, including similar studies not before conducted on Indonesian adolescent girls and a large sample of adolescent females from the West Bandung and Sumedang districts. However, some limitations need to be pointed out. First, Hb measurement in this study used the Hemocue method using capillary blood samples. The Cyanmethemoglobin method which was considered the gold standard might improve the accuracy. Second, the correlation between anthropometric parameters and Hb level was still unclear due to the design study was cross-sectional. Third, our study only involved adolescent girls who attended school in West Bandung and Sumedang districts. It may affect the generalization of the study results to all adolescent girls. However, this study could give insight that WHtR may be used as temporary early detection of anemia among adolescent girls aged 15–19 years in West Java

CONCLUSION

In summary, WHtR may has potential as a predictor of anemia status for adolescent girls with the optimal cut-off value being ≤0.44, although the results of the diagnostic test show low accuracy. This study also shows that adolescent girls of higher age and WHtR are less likely to experience anemia. This is the first study, and it is conducted on subjects who tend to be homogeneous, namely adolescent girls with Sundanese ethnicity. So further studies are needed on adolescent girls with different ethnic backgrounds to analyze the accuracy of the WHtR parameter in the early detection of anemia status.

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DECLARATION OF INTERESTS

The authors have no conflict of interest.

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Determinants of Poor Diet Quality among Elderly with Low Socioeconomic Status

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ABSTRACT

The purpose of this study was to evaluate the factors that contribute to the elderly with low socioeconomic status eating poor-quality diets. Two hundreds and ninety three (293) senior citizens, including 136 men and 157 women, were sought out from five districts in Kelantan. Data on socio-demography, medical history, empty nest, depressive symptoms and diet history were obtained through an interview-administered method. Anthropometry measurement including height, weight and circumferences (waist, hip, calf and mid-upper arm) were measured. Body composition were measured using body composition monitor to obtain muscle mass and fat mass. Blood pressure were measured using blood pressure monitor. The Asian Working Group for Sarcopenia (AWGS) algorithm was used to determine the diagnosis of sarcopenia. 48.8% of the participants were underweight. The majority of participants fell short of the suggested daily calorie consumption. 42% of the participants had poor diet quality according to Healthy Eating Index (HEI) score. Hypercholesterolemia and poor Short Physical Performance Battery (SPPB) score were found to be risk factors of poor diet quality. Therefore, nutrition interventions are important to help low-income families especially with older adults to improve their nutritional status for reducing risk of sarcopenia and chronic diseases.

Keywords: diet quality, elderly, low socioeconomic status, sarcopenia

INTRODUCTION

Population ageing is defined as a simultaneous decrease in the percentage and number of people under the age of 15 and an increase in the percentage and number of people aged 60 and older (Ismail *et al.* 2021). By 2035, the population of older adults aged 55 and older is predicted to outnumber all children aged 0 to 14 years, and by 2080, the population of older people is predicted to outnumber all children and teenagers aged 0 to 24 years (Harasty & Ostermeier 2020). Reduced energy expenditure, physiological and psychological changes, and chronic sickness are all associated with ageing and may have an impact on the dietary requirements of senior people (Leslie & Hankey 2015). Low Socio-Economic Status (SES) is yet another key factor that has an impact on the quality of older individuals' diets (Nazri *et al.* 2020). Also, according to Nazri *et al.* (2020), there are between 28.9% and 48% of senior people with low SES who are underweight.

Elderly people who are identified as empty nesters are referred to as those who live alone or only with their spouse, while their children may live far away or they may not have any children (Su *et al.* 2020). According to Gao *et al*. (2017), empty nest syndrome significantly harms elderly people's cognitive function, physical health, and psychological well-being. Depression is also the most prevalent mood disorder among elderly people. According to Mina (2017), 15% of the elderly experience depression. Sarcopenia eventually results from a loss of muscle mass brought on by depression, loneliness, and poor physical fitness (Yuenyongchaiwat & Boonsinsukh 2020).

According to Chen *et al.* (2020), sarcopenia is the age-related loss of both skeletal muscle mass and muscle function, which is measured by muscle strength or physical performance. The risk of malnutrition and poor appetite among the elderly has increased due to poverty, swallowing or chewing issues, unattainable healthy food, being unable to prepare food for themselves,

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polypharmacy, and social isolation (Rusu *et al.* 2020). Low dietary intake, both in quantity and quality, results in altered body composition, particularly a loss of lean muscle mass. Diet quality can be described as how well a person's food intake matches current recommendations (Putri *et al.* 2018). When compared to the elderly with a good appetite, individuals with a lack of appetite consumed more fats, sweets, soda, and dairy foods while consuming less energy, fibre, protein, fruits, and vegetables (Van der Meij *et al*. 2017). This condition is further worsened among older adults with low SES. According to previous studies, low SES was significantly associated with skeletal muscle loss (Dorosty *et al.* 2016; Jeng *et al.* 2018), which contributed to a decrease in physical performance and muscle strength. This condition might influence the ability to access and prepare food. In a vicious cycle, poor diet quality might amplify the risk of loss of skeletal muscle, especially among the elderly with low SES. Therefore, the current study aimed to investigate the association between diet quality and various health parameters, including empty nest, depressive symptoms, and sarcopenia, among the elderly with poor SES in Kelantan

METHODS

Design, location, and time

This study utilised a quantitative approach with a cross-sectional survey, which was conducted in five districts (Kota Bharu, Pasir Mas, Bachok, Machang, and Tumpat) in Kelantan, Malaysia. This study was conducted from 2020 to 2022 and obtained ethical approval on June 16, 2020, from the Jawatankuasa Etika Penyelidikan Manusia, (JEPeM), Universiti Sains Malaysia, with approval number USM/JEPeM/19070433.

Sampling

The convenience sampling method was employed in this research. A total of 293 participants were required based on sample size calculation using the simple proportion formula (Jacob *et al.* 2019) with a confidence level value of 1.96, precision set at 5%, and an additional drop-out rate of 5%.

Elderly aged 60 years and older, with a low education level (illiterate or with primary education) and low household income (<MYR 4,360) were recruited. Those on wheelchairs, with severe hearing or vision problems, severe health problems including end-stage renal failure on hemodialysis, stroke, cancer, amputees, severe depressive symptoms denoted by a Geriatric Depression Scale (GDS) score of 12 or higher, or those who were under-going physical rehabilitation or physiotherapy were excluded from this study.

Data collection

An interview-administered method was used to obtain the participant's information, including sex, ethnicity, age, employment and marital status, education level, living arrangement, household income, and smoking status. Self-reported chronic diseases were noted together with the medications consumed. A history of falls, either indoors or outdoors, for the past 12 months was also recorded. We also recorded participants' vitamin, mineral, or herbal supplement intakes. The Omron Blood Pressure Monitor was used to monitor their blood pressure. Participants were required to be seated at ease during the measurement.

The Body Composition Monitor HBF-214 was used to monitor weight. Stadiometer was used to measure height, which was recorded to the closest centimeter. Arm span was used to gauge height in older people with scoliosis. Height estimation using arm span was calculated using the formula by Shahar and Pooy (2003). By dividing weight in kilograms by the square of height in meters, the Body Mass Index (BMI) was determined. The Nutritional Screening Initiative (NSI) (1991) cut-off point for senior people served as the basis for classifying BMI.

Waist circumference was used to assess abdominal obesity. Men with readings of less than 90 cm or women with readings less than 80 cm have a high risk of cardiovascular disease. The width of the pelvis at the hip is measured as the hip circumference. The midway point between the tip of the acromion and the olecranon process distance circumference is measured as MUAC (Hu *et al.* 2021). Undernutrition was evaluated using MUAC, where values less than 23 cm and 22 cm, respectively, in men and women denote muscular wasting. Men's and women's calf circumferences had cut-off points of 30.1 cm and 27.3 cm, respectively, for measuring muscle mass loss. For analysis purposes, the mean of two readings was taken.

The Body Composition Monitor was used to monitor body composition. The Skeletal Muscle Index (SMI) needed to be calculated in relation to body composition. Men with low muscle mass were detected at 7 kg/m^2 and women at 5.7 kg/m^2 (Fung *et al*. 2019). The formula for SMI is:

$$SMI = \frac{Muscle\ mass}{Height^2}$$

Dietary History Questionnaire (DHQ) was employed to evaluate the elderly's regular food consumption (Rivan *et al.* 2022). The Healthy Eating Index (HEI), which was derived from the study by Karupaiah *et al.* (2013), was employed to determine the participants' dietary quality, with a score range of 0 to 100. In HEI, there were nine elements. Using the most recent Malaysian Food Pyramid 2020 for serving sizes of vegetables, fruits, milk and dairy products, cereals and grains, as well as poultry, meat, fish, legumes, and eggs, it was determined whether each component was in compliance. Additionally, four individual nutrient consumptions were also evaluated, including sodium, saturated fat, cholesterol, and total fat. Each group had a score between 0 and 10, which was determined proportionally for the in-between whole number responses. The formula for the overall score was:

$$\frac{Score\ derivide\ from\ the\ 9\ components}{90} \times 100\%$$

The overall HEI score is divided into three groups. Scores below 51 denote poor diet quality; scores between 51 and 80 denote intermediate or need for improvement; and scores above 80 indicate high diet quality.

Sarcopenia is defined as having reduced muscle mass and low skeletal strength or poor muscle performance, under the most recent Asian Work Group for Sarcopenia (AWGS) standards (Chen *et al.* 2020).

Severe sarcopenia is identified when the participant scores low in all three components. Hydraulic hand dynamometer was used to quantify muscle strength by measuring the hand grip strength. Men's and women's values of less than 28.0 kg and less than 18.0 kg, respectively, were used to indicate poor hand grip strength (Chen *et al.* 2020). The Short Physical Performance Battery (SPPB) was used to determine muscle performance. A balancing test, a sit-to-stand test, and a gait speed test were among the three sets of tests that were administered. Three different standing positions were used in the balance test, including tandem, side-by-side, and semi-tandem. The SPBB total score can be between 0 and 12. Better muscle function, particularly at the lower extremity, is indicated by a higher score (Yasuda *et al.* 2017). Low physical performance is identified for those who got less than nine points (Chen *et al.* 2020).

The state of the empty nest was assessed using a single-item statement that asked, "Whom are you living with?". According to Gao *et al.* (2017), the elderly was viewed as empty-nester if the response was alone or with a spouse.

To evaluate depressive symptoms, a 15-item Geriatric Depression Scale (GDS-15) was employed. There was a "yes" or "no" binary response option for each question. Participants who had a score of five or higher had a higher likelihood of experiencing depression symptoms.

Data analysis

Predictive Analytics Software (PASW) (IBM, United States) was used to enter and evaluate the acquired data. Based on the distribution of the data's normality, The Mean (SD) and Median (IQR) were reported. The frequency (%) of the category data was presented. For multivariate analysis, binary logistic regression was conducted to find predictors of low diet quality. Age and income were taken into account in the logistic regression model's adjustment for confounding variables. The p-value cut-off for significance was established at 0.05.

RESULTS AND DISCUSSION

The study has 293 participants in all. Table 1 displays the sociodemographic details of the participants. In this study, there were 157 women and 136 men. The majority of participants, 113 men (83.1%) and 91 women (58%), were married. In comparison to women (n=44, 28.0%), men (n=46, 33.8%) had a higher prevalence of empty nest syndrome ($p<0.001$).

Participants' anthropometry, body composition, blood pressure, sarcopenia, and depressive symptoms were displayed in Table 2. Men were found to be more likely to be underweight (56.6%) than women (42.0%), while women were more likely to be overweight (33.1%) than men (22.8%) ($p<0.05$).

Table 1. Sociodemographic details of participants (n=293)

Variables	Men (n=136)	Women (n=157)	Total (n=293)	*p*
Age[+]	69.5 (8.0)	68.0 (8.0)	68.0 (9.0)	0.069[a]
Income[++]			0.065[b]	
<MYR900	120 (88.2)	148 (94.3)	268 (91.5)	
MYR900−2500	16 (11.8)	9 (5.7)	25 (8.5)	
Marital status[++]				<0.001[b*]
Married	113 (83.1)	91 (58.0)	204 (69.6)	
Unmarried/Widowed	23 (16.9)	66 (42.0)	89 (30.4)	
Occupation (Current)[++]				<0.001[b*]
Government/Private/Self-work	57 (41.9)	28 (17.8)	85 (29.0)	
Unemployed	79 (58.1)	129 (82.2)	208 (71.0)	
Occupation (Previous)[++]				<0.001[b*]
Government/Private/Self-work	122 (89.7)	98 (62.4)	220 (75.1)	
Unemployed	14 (10.3)	59 (37.6)	73 (24.9)	
Education years[+]	7 (3.0)	7 (8.0)	7 (8.0)	0.189[a]
Living with[++]				<0.001[b*]
Spouse/Alone	46 (33.8)	44 (28.0)	90 (30.7)	
Spouse & child	71 (52.2)	60 (38.2)	131 (44.7)	
Child only	19 (14.0)	53 (33.8)	72 (24.6)	
Smoking status[++]				<0.001[b*]
Yes	64 (47.1)	0 (0.0)	64 (21.8)	
No	72 (52.9)	157 (100.0)	229 (78.2)	

[+]: Median (IQR); [++]: n (%); [a]: Mann-Whitney test; [b]: Pearson Chi Square; [*]: Significant at p<0.05

Men had a mean proportion of muscle mass in their bodies that was significantly higher than women's, at 30.0% and 24.4%, respectively. Additionally, men had a median Skeletal Muscle Index (SMI) of 6.9 kg/m^2 compared to women's 6.1 kg/m^2 (p<0.001), which was substantially higher in men.

Men's median handgrip strength for sarcopenia was 26.5 kg compared to women's 18.3 kg (p<0.001), which is a significant difference. Men (n=71, 52.2%) were substantially more likely than women (n=55, 35.0%) to have low muscle strength. It was discovered that the median gait speed test time was substantially longer in women than in men (p<0.001). Women took much longer to complete the sit-to-stand test than men did (p<0.001), which is another difference. The prevalence of poor physical performance as measured by SPPB was higher in women (n=114, 91.7%) than in men (n=93, 68.4%) (p<0.001). Women were less likely to have sarcopenia (n=28, 17.8%) than men (n=37, 27.2%). For the GDS score and subjective memory impairment, there was no statistically significant association with gender.

According to Nik Mohd Fakhruddin *et al.* (2016), energy intake below the 2.5th percentile and beyond the 97.5th percentile were signs of dietary under- and over-reporting. Out of 293 participants, 14 were removed from additional analysis because of under- and over-reporting. The overall dietary analysis, therefore, included 279 subjects. With 1,156.7 kcal/day and 1,032.0 kcal/day, respectively, the median daily energy intake of men (1,156.7 kcal/d) was substantially higher than that of women (1,032.0 kcal/d) (Table 3; p<0.001). The median protein (p=0.004), fat (p=0.025), carbohydrate (p<0.001), PUFA (p=0.002), MUFA (p<0.001), SFA (p<0.001), vitamin A (p=0.003), thiamin (p=0.002), niacin (p=0.001), riboflavin (p<0.001), vitamin E (p=0.002), folate (p=0.022), phosphorous (p<0.001), potassium (p=0.011), and zinc (p<0.001) were also significantly higher in men. However, women consumed more sugar (24.8 g/day) compared to men's (19.5 g/day), (p=0.025). Except for sodium, neither the men nor the women who were enrolled in this study met the micronutrient guidelines. Both men and women were found to consume more sodium than the RNI guideline.

The participants' average HEI scores were displayed in Table 4. Forty-two percent of participants reported eating diets of poor quality.

Table 2. Anthropometry, blood pressure, body composition, sarcopenia and depressive symptoms (n=293)

Variables	Men (n=136)	Women (n=157)	Total (n=293)	*p*
Anthropometry				
Weight[+]	60.7 (6.2)	55.6 (18.0)	58.6 (17.2)	<0.001[a*]
Height[+]	161.5 (9.2)	149.8 (7.3)	154.3 (12.9)	<0.001[a*]
BMI[+++]				0.039[c*]
Underweight	77 (56.6)	66 (42.0)	143 (48.8)	
Normal	28 (20.6)	39 (24.8)	67 (22.9)	
Overweight	31 (22.8)	52 (33.1)	83 (28.3)	
Waist circumference[+]	82 (17.5)	85 (19)	83 (18)	0.485[a]
Hip circumference[+]	90.5 (11.3)	92.5 (13.8)	91.5 (12)	0.161[a]
MUAC[+]	27 (5.1)	27 (5.6)	27 (5.4)	0.644[a]
Calf circumference[+]	32.4 (5)	31 (5.1)	31.7 (4.5)	<0.001[a*]
Blood pressure				
Systolic[+]	145.0 (37.0)	152.0 (30.0)	150.0 (35.0)	0.029[a*]
Diastolic[+]	78.5 (15.0)	80.0 (16.0)	79.0 (15.0)	0.288[a]
Body composition				
Muscle Mass (%)[++]	30.0 (2.3)	24.4 (2.4)	27.0 (3.7)	<0.001[b*]
Fat Mass (%)[+]	26.5 (5.4)	36.5 (6.8)	31.1 (10.4)	<0.001[a*]
SMI[+] (kg/m^2)	6.9 (1.7)	6.1 (1.0)	6.4 (1.4)	<0.001[a*]
Low Muscle Mass[+++]	72 (52.9)	56 (35.7)	128 (43.7)	0.003[c*]
Sarcopenia				
Handgrip[+] (kg)	26.5 (12.0)	18.3 (6.0)	21.5 (9.0)	<0.001[a*]
Low Muscle Strength[+++]	71 (52.2)	55 (35.0)	116 (39.6)	0.003[c*]
Balance Test Mark[+]	4.0 (0.0)	4.0 (0.0)	4.0 (0.0)	0.012[a*]
Gait Speed Time[+] (s)	6.0 (1.9)	6.6 (2.6)	6.3 (2.1)	<0.001[a*]
Sit-to-stand Time[+](s)	14.9 (4.2)	17.8 (4.4)	16.5 (5.0)	<0.001[a*]
SPPB Total Mark[+++]				<0.001[c*]
Poor physical performance	93 (68.4)	114 (91.7)	237 (80.9)	
Sarcopenia[+++]				0.007[c*]
No sarcopenia	67 (49.3)	106 (67.5)	173 (59.0)	
Sarcopenia	37 (27.2)	28 (17.8)	65 (22.2)	
Severe sarcopenia	32 (23.5)	23 (14.6)	55 (18.8)	
Depressive symptoms				
GDS[+++]				0.090[c]
Low Risk	104 (76.5)	106 (67.5)	210 (71.7)	
High Risk	32 (23.5)	51 (32.5)	83 (28.3)	

MUAC: Mid-Upper Arm Circumference; SPPB: Short Physical Performance Battery; BMI: Body Mass Index; SMI: Skeletal Muscle Index; GDS: Geriatric Depression Scale; [+]: Median (IQR); [++]: Mean (SD): [+++]: n (%); [a]Mann-Whitney test; [b]: Independent t-test; [c]: Pearson Chi Square; [*]: Significant at p<0.05

The median daily serving size of cereal for men was, however, significantly greater than for women, at 5.5 and 5.0, respectively (p<0.001). Although it was still less than the advised intake, the median daily serving size for protein meal among men was substantially higher than that of women, at 1.0 and 0.5, respectively (p=0.010). Men's overall fat and saturated fat consumption was significantly higher, with 40.7% and 6.5% of daily energy, respectively.

Those without sarcopenia had median HEI values that were substantially higher than those of sarcopenic and severely sarcopenic participants (55.56, 53.33, and 49.44, respectively) (p=0.043).

The results of the binary logistic regression that was carried out to identify the predictors of poor food quality are displayed in Table 5. Self-reported hypertension, high cholesterol, renal disorders, and diabetes, together with BMI, weight, SMI, SPPB, handgrip, sarcopenia, empty

Table 3. Energy and nutrients consumption adherence to the Malaysian RNI among the participants (n=279)

Nutrients[+]	Men (n=129)	RNI	% RNI	Women (n=147)	RNI	% RNI	*p*[a]
Energy (kcal/d)	1,156.7 (369.2)	2,030	57.0	1,032.0 (335.3)	1,770	58.3	<0.001*
Protein (g/d)	38.4 (13.6)	58	66.2	34.8 (13.9)	50	69.6	0.004*
Carbohydrate (g/d)	150.0 (56.7)	-	-	133.3 (48.4)	-	-	<0.001*
Fat (g/d)	40.7 (17.8)	56–68	72.7	37.8 (19.5)	49–59	77.1	0.025*
SFA (g/d)	6.4 (5.7)	-	-	4.6 (5.2)	-	-	<0.001*
MUFA (g/d)	2.4 (3.3)	-	-	1.4 (1.9)	-	-	<0.001*
PUFA (g/d)	1.0 (1.5)	-	-	0.7 (0.9)	-	-	0.002*
Fibre (g/d)	2.1 (2.2)	20–30	10.5	2.2 (1.9)	20–30	11.0	0.436
Sugar (g/d)	19.4 (25.6)	-	-	24.5 (21.2)	-	-	0.025*
Vitamin A (RE/d)	324.5 (424.2)	600	54.1	270.4 (232.7)	600	45.1	0.003*
Vitamin C (mg/d)	56.5 (81.9)	70	80.7	56.0 (51.7)	70	80.0	0.199
Vitamin D (µg/d)	0.7 (1.9)	20	3.5	3.9 (38.7)	20	19.5	0.465
Vitamin E (mg/d)	1.9 (2.2)	10	19.0	1.3 (1.2)	7.5	17.3	0.002*
Thiamin (mg/d)	0.5 (0.3)	1.2	41.7	0.5 (0.3)	1.1	45.5	0.002*
Riboflavin (mg/d)	0.8 (0.6)	1.3	61.5	0.6 (0.4)	1.1	54.5	<0.001*
Niacin (mg/d)	7.2 (3.9)	16	45.0	6.4 (2.9)	14	45.8	0.001*
Folate (µg/d)	61.1 (44.8)	400	15.3	50.5 (41.6)	400	12.6	0.022*
Sodium (mg/d)	1,380.8 (1,013.8)	1,200	115.1	1,352.3 (1,012.8)	1,200	112.7	0.397
Potassium (mg/d)	987.0 (511.4)	4,700	21.0	923.4 (552.0)	4,700	19.6	0.011*

RNI: Recommended Nutrient Intake; [+]: Median (IQR); [a]: Mann-Whitney test; *: Significant at p<0.05

Table 4. Total and component HEI scores (n=293)

HEI categories	Men (n=136)	Women (n=157)	Total (n=293)	*p*
Total HEI score[+]	54.4 (14.4)	53.3 (16.7)	53.3 (16.1)	0.766[a]
HEI rating[++]				0.219[b]
Poor	55 (40.4)	68 (43.3)	123 (42.0)	
Intermediate	81 (59.6)	89.5 (54.8)	167 (57.0)	
Good	0 (0.0)	3 (1.9)	3 (1.0)	
Serving per day				
Grouping A[+]				
Cereals	5.5 (2.5)	5.0 (2.5)	5 (2.5)	<0.001[a*]
Vegetables	0 (0.0)	0 (0.0)	0 (0.0)	0.870[a]
Fruits	0 (0.5)	0 (1.0)	0 (1.0)	0.126[a]
Dairy products	0 (0.0)	0 (0.0)	0 (0.0)	1.000[a]
Protein food	1 (1.5)	0.5 (1.0)	0.5(1.0)	0.010[a*]
Grouping B[+]				
Total fat	40.7 (17.9)	37.9 (19.1)		0.034[a*]
Saturated fat	6.5 (5.8)	4.6 (5.2)		<0.001[a*]
Cholesterol	31.6 (75.7)	25.4 (66.7)		0.280[a]
Sodium	1,382.4 (1,019.8)	1,361.1 (1,045.7)		0.448[a]

[+]: Median (IQR); [++]: n (%); [a]: Mann-Whitney test; [b]: Pearson Chi Square; HEI: Healthy Eating Index

nest, and GDS, were the independent variables for the model. Fourteen-point five percent (Nagelkerke R2) of the variation in the quality of the diet was shown in the model. An excellent match was found by the Hosmer and Lemeshow Test (p=0.086). According to Table 5, people with high cholesterol had a higher likelihood (2.4 times) to eat poorly than participants with normal cholesterol (95% CI:0.107–5.209; p=0.027). Additionally, a higher SPPB total score, which

Table 5. Risk factors of poor diet quality

Variables	B	S.E.	Exp (B)	95% CI for Exp (B)		*p*
				Lower	Upper	
High blood pressure	-0.332	0.388	0.718	0.336	1.536	0.393
High cholesterol	0.876	0.395	2.402	1.107	5.209	0.027*
Diabetes	0.426	0.424	1.531	0.668	3.513	0.314
Renal diseases	-0.046	0.857	0.955	0.178	5.122	0.957
Weight	0.039	0.031	1.040	0.979	1.104	0.205
Body mass index	-0.055	0.058	0.947	0.845	1.061	0.345
Skeletel muscle index	-0.049	0.266	0.952	0.565	1.605	0.854
Handgrip	-0.032	0.028	0.969	0.917	1.023	0.250
Short physical performance battery	-0.249	0.113	0.780	0.624	0.974	0.028*
Sarcopenia	-0.249	0.265	0.779	0.463	1.311	0.347
Empty nest	0.171	0.343	1.186	0.606	2.322	0.619
Geriatric depression scale	-0.475	0.380	0.622	0.295	1.309	0.211

Exp (B): Odd Ratio; SE: Standard Error; CI: Confidence Interval; Model has been adjusted for confounding factors including age and income
Dependent variable: HEI Score (0: Good and intermediate diet quality; 1: Poor diet quality); *: Significant at p<0.05

denoted superior physical performance, was linked to a lower risk of having a poor diet (95% CI:0.624–0.974; p=0.028).

The purpose of this study was to look into the predictors of poor diet quality among the elderly with poor SES.

In the current study, sarcopenia prevalence is 22.2%, and severe sarcopenia prevalence is 18.8%. According to a review by Woo *et al.* (2019), which covered Asian nations including Hong Kong, China, Taiwan, Malaysia, Singapore, Vietnam, and Indonesia, it was found that Hong Kong (16.6%), Taiwan (19.9%), and Singapore (13.7%) had the highest prevalence of sarcopenia among the elderly.

In the current study, the recommendations for energy and nutrient consumption for both men and women were not met. Similar findings were found in research conducted by Nik Mohd Fakhruddin *et al.* (2016) on 2,322 senior citizens in Malaysia, which found that neither men nor women met the RNI. Additionally, the current study discovered that men (1,156.7 kcal/d) consumed much more energy on a median basis than women (1,032.0 kcal/d). This finding is comparable to one made by Bennett *et al.* (2018) in a study among 200,000 adults from the United Kingdom, which found that men consumed significantly more energy and macronutrients, with a difference of 1,358 kJ in daily total energy consumption.

In addition, the current study discovered that women consumed substantially more sugar than men. This result is comparable to the results from the Bennett *et al.* (2018) study, which discovered that women were considerably more likely than men to consume more sugar than was advised.

The participants' median daily intake of dietary fiber, which is lower than the RNI's recommendation of 20–30 g, is low (2.1–2.2 g). Inadequate fiber consumption can cause constipation and poor bowel function, which can negatively impact quality of life (Kehoe *et al.* 2021).

Forty-two percent of the participants had poor diet quality in total. The overall mean HEI score was 79.3, according to Karupaiah *et al.* (2013) study of urbanised women in Malaysia. Due to a socioeconomic gradient in diet quality caused by the price of food, the current study's participants had lower HEI scores than those in the study by Karupaiah *et al.* (2013) (Darmon & Drewnowski 2015). Because these foods are more expensive than less nutritious food options, healthy food groups are less frequently consumed (Rao *et al.* 2013).

The reported median serving size for dairy products, vegetables, and fruits is 0, which is less than the advised serving. Given that the majority of participants in this research did not reach the recommended intake amount for the majority of the micronutrients and fiber, the poor HEI point for the components of fruits, vegetables, and dairy products may result in poor nutrition.

This research discovered that subjects without sarcopenia had considerably better

median HEI scores than sarcopenic and severely sarcopenic participants. According to Na *et al.* (2020), the group with a poor diet had a larger odd ratio of sarcopenia than the group with a healthy diet.

Low protein intake is a potential explanation for the link between sarcopenia and poor diet quality. The essential amino acids required for the synthesis of muscle protein are primarily found in dietary proteins. Age-related fast catabolism of muscle protein occurs in the body, and older people's protein intake has been linked positively to fat-free mass (Geirsdottir *et al.* 2013). For the elderly with sarcopenia, the Society for Sarcopenia, Cachexia, and Wasting Disease has advised balanced protein intake (1–1.5 g/kg/day), more energy intake, and amino acid supplementation (Noce *et al.* 2021). Additionally, the elderly without sarcopenia are advised by the European Society for Clinical Nutrition and Metabolism (ESPEN) to consume protein at a rate of 1.2–1.4 g/kg/day to help maintain their muscle mass and prevent sarcopenia (Deutz *et al.* 2014).

In addition, eating fruits and vegetables proved crucial for sarcopenia. According to Tan *et al.* (2018), fruits and vegetables are rich in antioxidant nutrients like vitamin C, magnesium, and vitamin E that have the potential to lower inflammatory markers like interleukin-6 and C-reactive protein. Antioxidant-rich diets may mitigate or even reverse the pathophysiological and cognitive changes that come with ageing. Inadequate antioxidant consumption and increased inflammation from poor diet quality may both have a deleterious impact on the pathophysiology of depression (Gopinath *et al.* 2014).

High cholesterol and an SPPB score are risk factors for poor diet quality, according to the study's adjusted binary logistic regression model. When compared to those with normal cholesterol levels, participants with high cholesterol had a higher likelihood (2.4 times) of having poor diet quality. This decreases the quality of their diet and raises the risk of hypercholesterolemia.

The current study also discovered that a decrease in the risk of poor diet quality was connected with higher SPPB total scores, which indicated good physical performance. According to a study by Robinson *et al.* (2018), older people who had better diet quality throughout adulthood performed physically better, with faster chair rise times and longer standing balancing times. Higher consumption of vegetables, fruit, and wholegrain bread are indicators of a diet with higher quality.

As far as we are aware, this is the first research to attempt to evaluate the quality of the diet among the elderly during the COVID-19 pandemic, specifically those with low SES. The risk factors for the diet quality of this particular population throughout the outbreak were also examined in this study. The current research was subject to a few limitations. First off, as this research used a cross-sectional design, it prevented the assessment of direction and the potential causation of association. Therefore, this research was unable to develop a causal relationship between diet quality and sarcopenia. Additionally, the fact that every participant in the current study is Malay may restrict the generalisability of the findings. Racial differences in diet quality may result from a variety of social and religious practices as well as other reasons.

CONCLUSION

In conclusion, as 42% of participants had low diet quality, the dietary quality of elderly with low socioeconomic status is concerning. Hypercholesterolemia and low SPPB score are the factors that determine a poor diet's quality. To prove a link between poor dietary quality and sarcopenia, longitudinal studies are essential.

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DECLARATION OF INTERESTS

The authors have no conflict of interest.

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Undernourishment Needs Overemphasis: Lived Experiences of Elementary Teachers and Parents Having Undernourished Schoolchildren

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ABSTRACT

This present study aimed to explore the lived experiences of parents and elementary teachers with undernourished children or pupils. These pupils are enrolled in two elementary schools in the 4th District of Santa Catalina under the Division of Negros Oriental, Philippines. Employing the descriptive phenomenological design through the unstructured in-depth interview method on the experiences of teachers and parents with undernourished schoolchildren, twelve participants agreed to participate in this study. Digitally recorded interviews were thematically analyzed to generate the themes and subthemes. We generated four themes: (a) pupils' poor class performance and behavior; (b) teachers' strategic initiative aimed at enhancing performance and behavior; (c) Department of Education's (DepEd) support for pupils' well-being; and (d) children's poor eating behavior. Teachers were challenged in handling pupils who are undernourished as the latter becomes mentally and physically absent in the classroom. To ensure that these pupils are not left behind, teachers make some interventions, like peer tutoring, to help the pupils cope with every day's lesson. With the intention of improving the nutritional status of undernourished pupils, schools implemented the school-based feeding program and the giving of nutritious foods that may be brought home for pupils' breakfast or supper. We conclude that despite the challenges encountered, teachers and parents devise interventions to lessen the negative effects of undernutrition with the help of DepEd.

Keywords: lived experiences, poor class performance, pupils' well-being, teachers' strategic initiative, undernourishment

INTRODUCTION

Child undernutrition is a serious international health issue (Leroy *et al.* 2020). Countries that have quickly progressed against maternal and child undernutrition have been cited as having a common success trait (Nisbett *et al.* 2015). There is no denying the effectiveness of micronutrient treatments that have significant, favorable effects on mortality, morbidity, and health, particularly for mothers, children, and babies (Allen 2014). Additionally, an abrupt drop in food intake or a sickness, both of which can be linked to drought exposure, are common causes of acute undernutrition, which is sensitive to recent drops in a person's weight (Belesova *et al.* 2019). The quality of intake and illness are two elements affecting a child's nutritional condition (Buntoro *et al.* 2017). Multiple micronutrient deficiency in undernourished children affect their ability to grow and operate at their best (Carboo *et al.* 2023). Poor appetite may be a significant sign of these issues and may serve as a helpful indicator of how well-recovered an undernourished child will be (Ickes *et al.* 2018).

Underweight, stunting, and wasting are the three types of undernutrition (Salleh *et al.* 2021). Undernutrition generally affects two billion people (Nisbett *et al.* 2014). High rates of stunting were linked to income, a mother's level of education, and the amount of money spent on food. The frequency of inadequate calorie intake and the proportion of food spent were linked to the incidence of high wasting. The number of mothers with low levels of education and the proportion of food expenditure were related to the prevalence of high underweight (Mauludyani *et al.* 2012). The population also plays a role in

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developing high-risk types of undernutrition, depending on their environment, lifestyle, and resources.

Early childhood undernutrition has been linked to poor cognitive development and some behavioral changes (Baker-Henningham *et al.* 2009). It increases the risk of sickness, delayed mental development, subpar academic performance, diminished intellectual capacity, and even death (Fufa & Laloto 2021). The academic progress of underweight children performs below their potential (Smith & Haddad 2015). Compared to non-undernourished children, undernourished children have a poor intellectual quotient, a high absence rate, and a high rate of grade-level repetition (Ali *et al.* 2022). Stunting, recurring infections, and cognitive impairment are just a few of the long-term health issues undernutrition has been linked to (Claus 2013). A severe physiological and cognitive deprivation that affects 165 million children under the age of five is stunting or being short for a child's age (Nisbett *et al.* 2014).

Recent studies focus more on undernutrition itself than on the experiences of the people who handle children who are undernourished. Aside from those who directly experience undernutrition, there is also a need to document the voices and experiences of people who deal with undernourishment indirectly, such as the teachers and parents. This study has the objective of unveiling the lived experiences of indirect undernourishment.

Currently, there are no studies on the lived experiences of teachers and parents dealing with undernourished pupils or children. Along with supporting parents who cannot give their children nutritious food, proper nutritional education for parents is necessary (Khanam & Haque 2021), including their challenges and some of their insecurities about being one. Researchers focus more on undernourished children, including the challenges encountered and interventions made. However, the scientific community must hear the teachers' and parents' experiences on the way they deal with the challenges associated to having undernourished children.

Thus, this research primarily aimed to investigate the lived experiences of teachers and parents with undernourished schoolchildren across grades one to six. The results of this study would help schools, communities, and the government understand the challenges and help teachers and parents with additional interventions that should be made. The output is expected to inform DepEd, the government, and the World Health Organization about Filipino teachers and parents' challenges, how they help their children, and the improvement of their undernourished schoolchildren.

METHODS

Design, location, and time

This study employed the descriptive phenomenological design using an unstructured in-depth interview method on the experiences of teachers and parents with undernourished pupils and children in Caigangan Elementary School and Amio Elementary School in Santa Catalina, Province of Negros Oriental, Philippines. We deemed this approach appropriate for this kind of study as it intends to explore significant experiences (challenges and interventions) narrated by the teachers, parents, or guardians. The best method for conducting this documentation is through descriptive phenomenology, which enables participants to speak freely and share their experiences in their own words. This study was issued with Ethics Clearance No. REA-2023-EXE-S-0037 by the Negros Oriental State University, Research Ethics Committee. All in-depth interviews were conducted in the month of April 2023.

Caigangan Elementary School (CES) is 15 km from the town proper and comprised 14 teachers and 369 pupils. Amio Elementary School (AES) is 18 km from the town proper and comprised 15 teachers and 349 pupils. These schools are small schools that are located in the rural area of Santa Catalina, with limited resources. Most of the children walk as their means of going to school, regardless of distance.

The pupils referred to in this study were those enrolled regardless of grade level in the two schools aforementioned. The identified undernourished children came from a medium-sized family with 4–7 siblings; most of them are the youngest in the family. They live in a small to medium-sized house made of light materials, like nipa and wood. Some live with their grandparents because of their separated parents, leaving the mother as the breadwinner; others live with their mothers only because their fathers are the

ones working in other cities and municipalities to provide for the family. The undernourished children at AES are residing near the main road, which is a 15-minute walk to the school (500 meters to one kilometer). On the other hand, undernourished children at CES are residing far from the main road with no accessible road from the main road to their house which is a 30–35 minutes walk to school (one to two kilometers).

Sampling

The researchers used 12 interviews as the base size for this study. Specifically, researchers interviewed six teachers and six parents of elementary grades 1 to 6 undernourished schoolchildren.

The following are the inclusion criteria for the in-depth interview: (a) must be a teacher, parent or guardian of undernourished individuals; (b) resident and teacher at CES or AES; (c) the child should be identified as undernourished by the Barangay Health Center or the adviser health monitoring form; (d) the child must be enrolled in any grade in the mentioned school. The exclusion criteria are as follows: (a) relatives of undernourished individuals who do not spend at least 24 hours in five days every week with the undernourished individuals, and; (b) teachers, parents or guardians of undernourished individuals who were not identified as undernourished by local health center or advisers' health monitoring chart.

Participant 1 is a 31-year-old female, married, and a Teacher I handling grade 5 at AES. She is currently studying for her master's degree at Cebu Technology University. She has been teaching at the said school for five years now; she graduated with the degree Bachelor of Elementary Education.

Participant 2 is a 34-year-old male, Teacher II, handling grade 6 at AES, a master's degree holder, and has been teaching for 12 years already. He resides in Barangay Amio, Sta. Catalina, Negros Oriental, near the school where he is currently teaching.

Participant 3 is a 28-year-old female, appointed as a Teacher III, handling grade 3 at AES. She has been teaching at the mentioned school for four years now; she is a graduate of Bachelor of Elementary Education.

Participant 4 is a 73-year-old grandmother residing at Proper Amio, Sta. Catalina, Negros Oriental, and a farmer on their mini-farm. She is a grandmother of fraternal twins, one of whom is identified as undernourished. She stood up as a mother since her daughter, the undernourished child's mother, works far from the barangay.

Participant 5 is a 53-year-old mother residing at Amio proper, Sta. Catalina, Negros Oriental, and a housewife. The undernourished child is her youngest child. Her husband works in Dumaguete City as the breadwinner of the family.

Participant 6 is a 50-year-old mother residing at Amio proper, Sta. Catalina, Negros Oriental, and a housewife. The undernourished child is her middle child. Her husband is an Overseas Filipino Worker (OFW) and the family's breadwinner.

Participant 7 is 42-year-old, mother of two children, and has been a Teacher II at CES for six years. She has been assigned to teach Grade 6 since then.

Participant 8 is a 38-year-old mother and a Teacher III for 11 years at CES. She is also a master's degree holder. She has been assigned to teach Grade 3 since then. She is residing near the school where she is teaching.

Participant 9 is a 30-year-old mother and Teacher II at CES for four years. She graduated with a Bachelor of Elementary Education, majoring in General Curriculum at NORSU-BSC.

Participant 10 is a 19-year-old sibling of the identified undernourished child from Caigangan, Sta. Catalina, Negros Oriental. The latter is a Grade 12 student of Obat High School. She is the current guardian since their parents work on their farm away from home.

Participant 11 is a 53-year-old mother from Caigangan, Sta. Catalina, Negros Oriental. She works at her own pace by selling random dishes around Caigangan. She also sells snacks such as bananaque and camoteque. She is also the mother of two children, including an undernourished child enrolled at CES.

Participant 12 is a 25-year-old mother of the identified undernourished child enrolled at CES. The family relies on the breadwinner's income who works in Dumaguete City for a living.

As to the recruitment process, the researchers employed snowball sampling or chain referral sampling as a technique in which personally known or existing subjects who met the inclusion criteria for this study were recruited

to participate as key informants in this project. They were encouraged to refer to the researchers some persons whom they know that would qualify as interview participants. Since the interviews were conducted face-to-face, the interviewer and interviewee strictly observed and complied with the minimum health standards required during the COVID-19 pandemic.

Data collection

Through in-person interviews, the participants were encouraged to speak openly and in their own words about their experiences having undernourished children at home or in school. Each interview lasted for at least 45 minutes. The project leader conducted all the interviews with the assistance of the project staff. The interviews were conducted in participants' houses or schools. Audio recording, transcription, translation, coding, and analysis were done after the interview. All transcripts are carefully verified by a bilingual translator proficient in Cebuano and English during the translation process. Triangulation took place, wherein after transcribing and translating, participants were able to see and verify their statements in English. The participants' comments and corrections regarding their statements that were included in the draft manuscript were duly considered before they formed part of this final paper.

Data analysis

Digitally recorded interviews were transcribed. Thematic analysis was then utilized in analyzing participants' experiences. An inductive approach was utilized, wherein researchers allowed the data to determine the themes. Specifically, the analysis proceeded using six steps developed by Braun and Clarke (2021). The process includes the following steps: (1) familiarizing with dataset; (2) coding; (3) generating themes; (4) reviewing themes; (5) defining and naming themes, and; (6) writing up.

RESULTS AND DISCUSSION

DepEd classified two types of below-normal or undernourishment in their nutritional status chart: wasted and severely wasted. Every child is classified according to their BMI-for-age. Through the thematic analysis of the in-depth interview transcripts, the researchers generated four themes to highlight the experiences, specifically the challenges encountered and primary interventions made by elementary teachers and parents who have undernourished children or pupils. These themes are: (a) pupils' poor class performance and behavior; (b) teachers' strategic initiative aimed at enhancing performance and behavior; (c) DepEd's support for pupils' well-being, and; (d) children's poor eating behavior.

Theme 1: Pupils' poor class performance and behavior

The first theme captures the poor performance and behavior of undernourished pupils in the class. This serves as a challenge in handling pupils identified as undernourished, as reflected in the following subthemes: mental absenteeism, and physical absenteeism.

Mental absenteeism. When a pupil physically enters a class, it does not mean they are ready. Going to school is part of a child's daily routine; however, it is not assured that their minds are ready when they step into their classrooms' doors. It may be put up as "physically present but mentally absent." A teacher, for example, recounted:

"Their school performance is affected early in the morning, they [undernourished children] don't have the energy and are tired already" (Participant 7, personal interview, 13 April 2023).

Teachers see that their pupils lack of energy and are tired first thing in the morning. Meanwhile, the teachers shared the experience of almost all the teachers in the two schools being able to notice the poor performance and behavior of pupils. Undernourished pupils tend to have slow cognitive skills that affect their academic development. Nutrients deficiency causes mental absenteeism, which causes poor academic development. A participant added:

"Nutrition can affect a child's performance. The slower their brain works, the slower their academic development is" (Participant 7, personal interview, 13 April 2023).

Once a child enters a classroom tired and apathetic, it results in poor participation during class. Regardless of grade level, teachers come up with the same observation: participation is the common element undernourished pupils tend to lack. Another teacher added:

"They [undernourished children] seem weak, and they could not often participate in class" (Participant 1, personal interview, 12 April 2023).

In the same observation made by teachers, a teacher also said that:

"Sometimes they [undernourished children] don't participate; others will just stare" (Participant 9, personal interview, 13 April 2023).

A teacher of a different grade level observed that:

"Undernourished children who were mentally absent were affected academically. They could not process information quickly" (Participant 2, personal interview, 13 April 2023).

Moreover, another teacher observed the same thing.

"His [undernourished child] memory is slow; it takes moments for him to understand" (Participant 8, personal interview, 13 April 2023).

Physical absenteeism. Teachers are challenged by pupils' poor performance inside the classroom. They grapple with undernourished pupils who seldom appear in class. Being physically absent also dramatically impacts their class performance. Classroom advisers are already questioning why they have dropped out pupils. Although this was an uncontrolled decision by the pupils who dropped out, advisers are still held responsible for their reasons for doing so. A teacher mentioned:

"As reported at the beginning of the school year, two undernourished [pupils] are no longer attending school, or shall we say they have already dropped out" (Participant 7, personal interview, 13 April 2023).

On the other hand, normal absences that do not fall under dropping out are observed by teachers. A teacher said:

"Some [undernourished pupils] are always absent" (Participant 3, personal interview, 13 April 2023).

It is observed that most absences come from undernourished pupils. A participant added:

"There are [undernourished] pupils who have an average [absence rate] of 60% in one school year" (Participant 2, personal interview, 13 April 2023).

Undernourished children have reasons for their absences, and most of their reasons appear to be because of sickness. According to a teacher, she said:

"[Undernourished pupils] will absent because they feel sick; this is their number one reason" (Participant 9, personal interview, 13 April 2023).

Theme 2: Teachers' strategic initiative aimed at enhancing performance and behavior

The second theme reveals the strategic initiative taken by teachers to enhance undernourished pupils' poor performance and behavior. Teacher make interventions to make sure that undernourished pupils will not get left behind, including encouragement given by teachers to all the undernourished pupils. As one teacher said:

"My everyday advice to them [undernourished children] is to sleep early, have a balanced diet, avoid junk foods, and exercise daily" (Participant 1, personal interview, 12 April 2023).

For teachers, it is natural to look after their pupils' well-being. Another teacher added:

"Encourage the children [undernourished children] that they should eat fruits and vegetables at home. They [undernourished children] should also sleep early so that their health status will change into normal" (Participant 7, personal interview, 13 April 2023).

To make learning effective, teachers have a duty to make it as fun as possible. It is their responsibility to ensure pupils learn and have fun at the same time. Moreover, with undernourished pupils, having fun while learning is challenging for teachers. Reinforcement of strategies is a must. A teacher, for example, said:

"*You should always be alive, alert, and enthusiastic because you do not know if your pupils already have breakfast. So, it would help if you were energetic when starting the class so the pupils would feel energetic. And then you should include games in your activities because, through games, the pupils will be more participative, energized, and motivated. Adding rewards to your activities makes the pupils more participative"* (Participant 1, personal interview, 12 April 2023).

Teachers also reinforced peer tutoring, allowing the undernourished pupils to cope with every day's lesson. A teacher added:

"In our everyday lesson, motivation is included to catch their attention. We involve activities such as peer tutorials or group discussions because we cannot hold time for all

of the pupils in one class. We also encourage them to participate in school activities to gain grades, because if they just sit and stare, they will only get low remarks" (Participant 9, personal interview, 13 April 2023).

This strategy is also utilized by teachers who cannot make time for one-on-one remediation with undernourished pupils. She said:

"I give them [undernourished children] peer tutors; a classmate who's good at class will be sitting beside wasted and severely wasted children" (Participant 7, personal interview, 13 April 2023).

Theme 3: DepEd's support for pupils' well–being

DepEd implemented programs as an intervention to address undernourishment. Its support for pupils' well being is further captured in the following subthemes: Department of Education program, and improvement of nutritional status of undernourished pupils.

Department of education program. Other than knowledge, they will also be equipped with protection. Aside from medical supplies, DepEd also implemented a program for undernourished pupils. As stated by a teacher:

"With regard to their [undernourished children] health, we always prioritize them [undernourished children] because in every school year, they are included in the budget of MOOE (Maintenance and Other Operating Expenses) for medical supplies, such as vitamins and paracetamols" (Participant 1, personal interview, 12 April 2023).

Concerning the program that gives undernourished pupils nutritious food to improve their nutritional status, a teacher stated:

"We have this program called SBFP (School-Based Feeding Program)" (Participant 3, personal interview, 13 April 2023).

Teachers are most grateful for DepEd's implementation of this program. A teacher expressed:

"I am happy because these children will be given food through the SBFP, as well as food that they can bring into their house for breakfast or lunch" (Participant 9, personal interview, 13 April 2023).

Teachers became emotional when they saw their pupils with nothing to eat. They also have limitations as much as they want to help. That is why the program at DepEd brought them such joy. A teacher also added:

"As a teacher, I don't have money to feed them [undernourished children]. My joy is that they will be given allocations by the SBFP" (Participant 9, personal interview, 13 April 2023).

Another teacher expressed her commendation:

"Feeding program is a big help to get the children to engage more in activities" (Participant 8, personal interview, 13 April 2023).

Implementing a program is a sure hit for teachers since they know their department backs them up. It is not just them who care but also the higher authorities.

Improvement of the nutritional status of undernourished pupils. During the program's implementation, the nutritional status of undernourished pupils is expected to improve—even a bit. According to a teacher:

"There are some of them [undernourished children] who gained more weight" (Participant 2, personal interview, 13 April 2023).

A teacher observed:

"In my 4 years here, yes, there are improvements. Some children [undernourished] graduated [from being undernourished] and there are some [undernourished children] who stayed [as undernourished]" (Participant 3, personal interview, 13 April 2023).

As teachers observed improvements, they also empathized with undernourished pupils, especially those who show no improvement.

Another teacher claimed:

"There is an improvement in nutritional status because of the SBFP by DepEd…" (Participant 1, personal interview, 13 April 2023).

Theme 4: Children's poor eating behavior

In undernourished pupils' respective homes, parents also observe their terrible eating habits and struggled to make their children eat. They also know that poor eating habits result in poorly nourished children who tend to have weaker immune systems. Sucking is also a process to break down food. However, sucking food instead of chewing takes too much time; children lose their appetite afterward, which results in less food and less nutrient intake. A struggling parent stated:

"He [undernourished child] rarely eats, because he sucks the food every time he eats" (Participant 6, personal interview, 13 April 2023).

Some parents also observed:

"He [undernourished child] is a slow eater, and when he eats, he chooses his food" (Participant 10, personal interview, 13 April 2023).

In this case, an undernourished child eats slowly, which also takes too much time, which may result in losing their appetite. The child was not a picky eater; however, he disliked eating. Given that the child also picks food he wants to eat over the food he needs to eat, another parent stated this observation:

"He [undernourished child] is not a picky eater, but he doesn't like to eat" (Participant 11, personal interview, 13 April 2023).

Nutrients are primarily found in vegetables. However, children usually eat to satisfy their cravings rather than the nutrients their body needs. Another parent added:

"He [undernourished child] does not eat vegetables. He won't even try the soup" (Participant 12, personal interview, 13 April 2023).

There is a causal link between poor behavior and academic performance. Poor behavior and performance in class may both be caused by undernourishment. Our generated result strongly agrees with the statement that childhood undernutrition's long-term effects include diminished physical ability for labor, lower intellectual quotients, a higher risk for illness and mortality, and cognitive impairment (Ali *et al.* 2022). Undernourished children are more prone to experience delayed cognitive development, which can cause attention and learning issues. They are also prone to fatigue, making it challenging to concentrate and participate in class. Undernourished schoolchildren can also be less motivated to learn, as they may feel they need more energy to do so. Meeting their nutritional needs directly contributes to their capacity for engaging in classroom activities. If they lack even the energy to even participate, then their potential as successful students will remain unfulfilled. This idea is further supported by the finding that Fufa and Laloto (2021) established, stating that early childhood undernutrition increases the risk of sickness, delayed mental development, subpar academic performance, diminished intellectual capacity, and even death.

Teachers play a vital role in enhancing the performance and behavior of undernourished children. One of their roles is to take good care of their pupils. Ayyaz *et al.* (2021) emphasized that understanding and recognizing the risk factors will be very beneficial for efforts to avoid undernutrition. They are responsible for monitoring and evaluating children for them to be aware of their nutritional status.

Teachers' strategic initiative includes encouraging students to engage in physical activity during breaks, Physical Education class, and other school events. It should be noted that the value of a healthy diet and how to make healthy food choices can be taught to students and their families by teachers. One of the teachers' ways is to give details on government initiatives that help low-income families with their food needs. As educators, informing and teaching is their expertise and they could explain it in a way that is suited to a child's level of understanding. Ultimately, it will be up to the family and the children themselves to acquire the much needed nutritional intake along with some assistance or government programs, the children's needs could be met.

Government policies and initiatives meant to promote health must consider the provision of wholesome, suitable, and inexpensive food products (Mohseni *et al.* 2019). This idea is further supported by the finding in this study that the government has assigned an agency in charge of basic education programs, the DepEd of the Philippines. Together with DepEd, there is also an alliance with the United Nations International Children's Emergency Fund (UNICEF), which assists governments and other organizations in raising awareness of the issue of undernutrition. Another alliance is with the World Health Organization (WHO), an international leading authority concerned with public health. Malaysia also has the Ministry of Education as the agency focusing on basic education. The Ministry of Education of Malaysia has integrated an intervention wherein food handlers in every school canteen and a nutritionist collaborate to ensure they serve an appealing and healthy menu for the schoolchildren (Teo *et al.* 2019). DepEd has an alliance with international organizations; however, they still need to implement a collaboration of public-school food handlers and nutritionists.

The present study's results strongly imply that children's poor eating behavior can lead to

undernourishment, a serious health problem that can have long-term consequences, not only in terms of their physical wellbeing, but their mental and cognitive wellbeing as well. Scaglioni *et al.* (2018) emphasized that parental food choices and feeding strategies are the most dominant determinants of a child's eating behavior and food choices. Thus, teachers being the adult role models next only to their parents should lead and guide the children about their nourishment needs and what could happen if they fail to meet them. This idea is further supported by the finding in this present study that schoolchildren are picky eaters and do not care about the health benefits. However, with parental guidance and feeding strategies, there is a considerable chance that schoolchildren will consume a balanced diet.

Elementary teachers and parents experienced challenges with undernutrition among schoolchildren. This finding will pave the way for everyone to know what difficulties teachers and parents encountered that made them carry the burden of undernutrition. Teachers carry the burden of improving nutrition intake among undernourished pupils to help them catch up with everyday lessons. On the other hand, parents also strive hard to improve their children's nutrition. Despite challenges encountered by teachers and parents, along with the DepEd, they have devised interventions to solve the undernutrition problem. A program was implemented by DepEd for teachers to monitor the progress and for parents to make sure that the pupils or children have enough intake of vitamins and nutrients from food.

Monitoring children's health should thoroughly evaluate their nutritional status to spot kids and teens at risk for nutrition problems (Więch *et al.* 2022). Thus, understanding and recognizing the risk factors will be very beneficial for efforts to avoid undernutrition (Ayyaz *et al.* 2021). To reduce childhood undernutrition, it is preferable to focus on healthy eating habits and active lifestyles (Ali *et al.* 2022).

Even though stunting, underweight, and wasting were relatively rare (5%), the existing approach to child nutrition needs to be strengthened (Zhang *et al.* 2022). The number of mothers with low levels of education and the proportion of food expenditure were linked to the prevalence of high underweight among children (Mauludyani *et al.* 2012). It is essential to implement nutrition education and school feeding programs, enhance drinking water infrastructure, and boost the local economy to address undernutrition (Berhanu *et al.* 2023). However, nutrition-based interventions alone cannot address the burden of undernutrition unless there is a concurrent emphasis on underlying determinants (Das & Salam 2019). Parents' educational level, employment position, the child's age, a lack of appetite, vaccination history, and recurrent diarrhea all affect wasting (Danso & Appiah 2023).

Along with support for parents who cannot give their children nutritious food, proper nutritional education for parents is necessary (Khanam & Haque 2021). For the family head and households, government policies and initiatives to promote health must consider providing wholesome, suitable, and inexpensive food products (Mohseni *et al.* 2019). It was also suggested that strengthening family nutritional counseling and family planning program sensitization should be a priority for all stakeholders (Nugusse *et al.* 2022). Furthermore, the Sustainable Development Goal for better nutrition and eradicating all forms of undernourishment by 2030 states that children with Severe Acute Malnutrition (SAM) have a high risk of illness and developmental delays contributing to widespread morbidity and mortality, particularly in the developing countries. The current progress is insufficient to achieve this goal (Kumar *et al.* 2023).

CONCLUSION

Teachers observed two types of challenges among their students who are undernourished: mental absenteeism and physical absenteeism. Moreover, parents have encountered challenges as they have observed the poor eating habits of their children. Despite the challenges encountered, teachers and parents devise interventions to lessen the burden of undernutrition with the help of DepEd, which implemented some programs to help address undernutrition. Teachers also always motivate pupils to strive more regarding their nutrition and academics. Therefore, the cooperation of elementary teachers, parents, and other community members has a huge role in guaranteeing that all children have the opportunity to attain their full potential, by improving their nutritional status. Some unique

obstacles that elementary teachers and parents encounter while dealing with undernourished pupils are: undernourished pupils having difficulty concentrating in class, undernourished pupils more likely get sick, and undernourished children may feel isolated and ashamed therefore affecting them socially and emotionally.

For the practical utility of the data generated from this study, more emphasis and support should be provided by the government to teachers and parents in dealing with undernourishment. Parents' nutritional education is also a viable intervention that would help address undernutrition.

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Potential Maternal Risk Factors for Low Birth Weight in Indonesia: A Systematic Review

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ABSTRACT

This review was conducted with the aim of summarizing the articles on the potential maternal risk factors for Low Birth Weight (LBW) in Indonesia. All observational studies conducted in Indonesia between 2010 and 2022 were thoroughly reviewed in this study. The articles were retrieved from "PubMed", "ScienceDirect", "Web of Science", and "Garuda". The retrieval was supplemented by snowball sampling technique. This review was constructed according to the PRISMA guidelines and the quality of the articles was assessed according to the STROBE guidelines. Of the 129 articles, only 12 articles met the inclusion criteria. Maternal variables such as education (50%), household wealth (33.3%), nutritional status (33.3%), age (25%), pregnancy complications (25%), marital age (16.7%), gestational weight gain (16.7%), ANC visit (16.7%), weight at third trimester (16.7%), twin birth (16.7%), birth interval (16.7%), iron supplementation (8.3%), parity (8.3%), and anemia status (8.3%) were found to be the risk factors for LBW incidence. This review found that almost all potential maternal risk factors contributing to LBW are preventable. It may help policy makers to design a more effective LBW prevention intervention and early risk identification for pregnant women. Appropriate follow-up by health workers for clinical intervention will also help to improve their pregnancy outcomes.

Keywords: Indonesia, low birth weight, maternal, pregnancy, risk factors

INTRODUCTION

Data from the Indonesian Demographic and Health Survey (IDHS) 2017 showed that the trend of Infant Mortality Rate (IMR) decreased by 25% from 32 per 1,000 live births to 24 per 1,000 live births (IDHS 2017). The target of the National Long and Medium Term Development Plan (RPJMN) is to achieve an IMR of 16 per 1,000 live births by 2024. In order to achieve this, it is important to address one of the major contributing factors to IMR, which is Low Birth Weight (LBW).

According to the 2018 Basic Health Survey (Riskesdas) report, the prevalence of LBW in Indonesia was 6.2% (Ministry of Health Republic of Indonesia (MoH RI) 2018). However, there are some provinces in Indonesia where the prevalence is still higher thatn the national prevalence, such as Central Sulawesi (8.9%) and North Maluku (8.7%) (Badan Penelitian dan Pengembangan Kesehatan (Balitbangkes) 2019). Compared to newborns with normal birth weight, newborns with LBW are 3.38 times more likely to experience stunting during childhood (Fakhrina *et al.* 2020). Several strategies and programs have been implemented to overcome low birth weight, such as health education, supervision and monitoring, measurement of maternal nutritional status, and antenatal care program (Pristya *et al.* 2020), but nowadays LBW is still widely recognized as a serious public health problem, particularly in developing countries such as Indonesia.

It is well established that maternal characteristics, namely maternal nutritional

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status, marital age, and Antenatal Care (ANC) visits, influence the pregnancy outcomes. Neonatal nutritional status is influenced by maternal nutritional status as measured by Body Mass Index (BMI) and Mid Upper Arm Circumference (MUAC). Early marriage among women, resulting in early pregnancy, also affects the birth weight. Early maternal age at the time of conception increases the risk of LBW because the mother is not mature enough and also shows inefficiency in the placental transfer mechanism as compared to a young adult. In addition, the reproductive organs of women under the age of 20 are also not in optimal condition to carry a baby (Kamini & Avvaru 2014). All these factors can have a lasting impact on the health and physical status of the growing baby.

Fortunately, several predictors of LBW are preventable (Lutfitasari & Mulyanti 2023), and this review will focus only on the preventable maternal risk factors for LBW incidence. This systematic review aimed to provide a summary of the maternal risk factors influencing LBW and hopefully the results will facilitate the health authority in planning appropriate intervention program to minimize the LBW incidence, such as promoting maternal health services by developing screening tools to predict LBW risk since early pregnancy. The results of this review may also be useful for other developing countries with LBW problem.

METHODS

Design, location, and time

The study design was a systematic review. Studies that were published in the last ten years (2012–2022) were retrieved from four scientific literature databases: PubMed, ScienceDirect, Web of Science, and Garuda. In addition, the snowball technique was also used to search for other articles from references listed in related studies. This study follows the PRISMA guideline (Moher *et al.* 2009).

Study selection (Screening)

All screening processes were based on the following inclusion and exclusion criteria. The inclusion criteria were: 1) peer-reviewed observational studies written in Indonesian or English; 2) studies conducted in Indonesia; 3) full text and open access published between 2012–2022 (last ten years). The search terms used were: "factors", "Indonesia", "low birth weight", "pregnancy". Non-original research studies, reviews, and short communication articles were excluded.

Data collection

Data collection was based on the procedure recommended by Rethlefsen *et al.* (2021), which included the following four steps: 1) data were collected by using a search engine with specific keywords and Boolean operators in English such as (potential risk factors or maternal risk factor) and (low birth weight or LBW infant) and (Indonesia); 2) the title, abstract, and keywords of the selected articles were analyzed according to the eligibility criteria; 3) these articles were partially or fully read to determine whether they met the inclusion criteria or not; 4) the reference of the selected articles were scanned to identify relevant studies.

Through a cycle of recurring author assessments, the five authors collaborated on the data collection. All records were screened by titles and abstracts obtained from the search engine. Studies that met the inclusion criteria were selected. At least two of the five authors in the article screening process agreed on the selection of the manuscript. Any disagreements among the authors were discussed until agreement was reached.

Zotero Standalone software was used to manage the references. The following steps were performed on the selected articles: excluding duplicate articles, checking the title and abstract of the article to ensure that it met the inclusion criteria, reading the entire article and implementing the exclusion criteria, and manually searching the references of the selected articles. These steps were performed by two reviewers. Each selected article was then manually extracted into a table as shown in Table 1. A total of 129 articles were obtained, but only 12 articles met the inclusion criteria (Figure 1).

Data analysis

Five criteria, based on the STROBE recommendations for cross-sectional studies (Malta *et al.* 2010) and the Newcastle-Ottawa Scale for cohort and case-control studies (Wells *et al.* 2017), were used to assess the quality of the selected articles (Table 2). One point was

assigned for each criterion met. The final score could range from zero to five (Barreto *et al.* 2019). The summary table for this review was created manually from each selected study by extracting from that included information about the journal author (year), location, population, type of study, statistical method, results, and quality assessment (Table 1).

RESULTS AND DISCUSSION

Twelve articles were selected for review after meeting the inclusion criteria for this study. Table 1 shows these twelve selected articles. The STROBE checklist was used to examine the consistency of reporting of all studies and outcomes from zero to five, as shown in Table 2 (Barreto *et al.* 2019).

The results revealed that all articles for the review were from studies conducted in western, central, and eastern parts of Indonesia (Table 1). The maternal variables consist of education, household wealth, nutritional status, marital age, maternal age, Gestational Weight Gain (GWG), ANC visits, pregnancy complications, iron supplementation, parity, anemia status, third trimester weight, family income, twin birth , and birth interval.

As shown in Table 2, only two studies met all established quality criteria, whereas ten

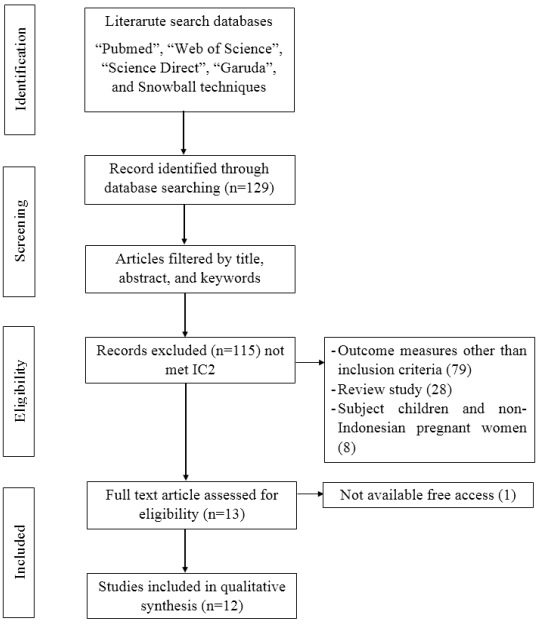

Figure 1. Flowchart for selection of articles

studies did not. Ten articles studied birth weight without adjusting LBW for Gestational Age (GA) or independently studied preterm birth and Intrauterine Growth Restriction (IUGR). Among the five points for analyzing the quality of articles, the lowest score was did not adjust LBW for GA or independently analyzed IUGR and prematurity.

The studies investigated risk factors associated with LBW in Indonesia, and the most common maternal risk factors identified included education (six articles, 50%), household wealth (four articles, 33.3%), nutritional status (four articles, 33.3%), age (four articles, 25%), and pregnancy complications (four articles, 25%). Other risk factors identified to be associated with LBW were marital age (two articles, 16.7%), GWG (two articles, 16.7%), ANC visits (two articles, 16.7%), third trimester weight (two articles, 16.7%), twin birth (two articles, 16.7%), and birth interval (two articles, 16.7%). An association was also found between iron supplementation (one article, 8.3%), parity (one article, 8.3%), and anemia status (one article, 8.3%) and LBW incidence in Indonesia (Table 1).

Malnutrition during pregnancy affects the development and the growth of the fetus. According to the fetal origin disease hypothesis, fetal adaptation to the malnourished environment or placental insufficiency causes hypertension, insulin resistance, dyslipidemia, heart disease, and non-insulin-dependent diabetes in adolescents (Hocher 2014). Fetal programming can influence future disease because the body's memory of malnutrition during a critical period is manifested in the pathology that causes future disease (Barker 1995).

Furthermore, among the modifiable determinants of LBW, maternal education is one of them. The incidence of LBW is associated with the level of maternal education (Sebayang *et al.* 2012; Paramitasari *et al.* 2018; Supadmi *et al.* 2020; Azinar *et al.* 2022; Okriyanto *et al.* 2022; Wulandari *et al.* 2022). A study by Nuryani & Rahmawati (2017) also showed that LBW was associated with maternal education. High level of education would allow mothers to get necessary information about prenatal care, infant care, and also nutritional fulfillment (Bhaskar 2015).

Household wealth is also associated with the incidence of LBW. Among women with older Age at First Marriage (AFM) (>35 years old)

Table 1. The general characteristics of the twelve selected studies

Author (year)	Location	Population	Type of study	Statistical method	Result	Quality assessment
Sebayang *et al.* (2012)	Lombok	Data from The SUMMIT; the total respondents were 14.040 for LBW analysis with 13.498 data for preterm births and 13.461 data for SGA births.	A double-blind cluster-randomized controlled trial.	Software: SAS PROC GENMOD Hierarchical logistic regression partial PAR.	Determinant of maternal factors of LBW were education, height, residence, MUAC, season at birth, household wealth, and pregnancy interval.	4
Anggondowati *et al.* (2017)	East Java	650 data of women and their baby.	Observational prospective cohort study.	Software: SPSS 17.0 Multivariate analysis.	The risk of LBW, VLBW, stillbirth and neonatal death was reduced by referral from a care facility.	5
Soltani *et al.* (2017)	Western Sumatra	607 pregnant women, recruited in 2010.	Observational cohort study.	Software: SPSS 24.0 Logistic regression, multivariate logistic and linear regression Level of significance: $p<0.05$.	Obese women were more likely to deliver macrosomia infant compared to those with a normal BMI. Meanwhile, for women with inadequate GWG, they were having greater probability to deliver LBW and premature infants.	5
Paramitasari *et al.* (2018)	Madiun General Hospital, East Java	200 newborn babies consist of 50 LBW infants and 150 infants with normal weight.	Analytical observational study with a case-control design.	Software: STATA 13 Path analysis.	The incidence of LBW were significantly increased with anemia, multiparity, and maternal age <20 or >35 years. In the other hand, the incidence of LBW was significantly decreased with good maternal nutritional status, maternal education ≥high school, and wide birth space.	3
Supadmi *et al.* (2020)	34 provinces in Indonesia	Data from 2017 IDHS. By using sample stratification and multistage random sampling, there were 1,741 women aged 15–49 who gave birth in 5 years prior to the survey as respondents.	Cross-sectional study design.	Software: SPSS 22.0 Chi-Square, Binary logistic regression.	The significant predictors of LBW infants in Indonesia were ANC visits, maternal educational level, age group, and maternal wealth status.	3
Adawiyah *et al*. (2021)	Kanjilho Health Center, South Sulawesi	150 pregnant mothers visited in 2019.	Cross-sectional with secondary data.	Univariate, bivariate, multivariate as well as ROC curve.	The weight 60.5 kg at third trimester can predict LBW.	3

Continue from Table 1

Author (year)	Location	Population	Type of study	Statistical method	Result	Quality assessment
Djokosujono *et al.* (2021)	Anny Rahardjo Maternity Clinic's registry, Jakarta, Indonesia	278 pregnant mothers who visited clinic in 2017–2018.	Cross-sectional study.	Correlation, Logistic regression analysis Level of significance: p<0.05 ROC.	Weight at early third trimester is s ignificantly associated with LBW. The minimum weight is 59.8 kg AUC=0.68, Se 67%, Sp 63%).	3
Maulinda *et al.* (2021)	34 provinces in Indonesia	4,561 women aged 15–49 years from 2017 IDHS who where married and delivered a baby within the 5 years preceding the survey.	Cross-sectional study design.	Binary logistic regression binomial probit regression.	AFM affected the likelihood of childbirth complications and LBW babies Low or high AFM increased the risk of having LBW newborn.	4
Aji *et al.* (2022)	West Sumatra	195 pregnant women.	Observational cohort study analysis.	Software: SPSS 23.0 Chi-Square test, One-way ANOVA, Logistic regression, Level of significance: p<0.05.	Mother with pre-pregnancy BMI in overweight/obese category were more likely to have an excessive GWG than those whose weight was normal, and more likely to have macrosomia newborn. For the mother with inadequate GWG were more likely to have LBW infant.	5
Azinar *et al.* (2022)	Grobogan District, Central Java	First child born to a woman aged less than 30 years from January 2020 to July 2021 (n=3,400).	Observational cohort retrospective study.	Chi-Square test.	The maternal risk factors associated with LBW were maternal educational level, place of residence, employment status, and age at the first marriage.	3
Oktriyanto *et al.* (2022)	Madiun General Hospital, East Java	200 newborn babies consist of 50 LBW infants and 150 infants with normal weight.	Analytical observational study with a case-control design.	Software: STATA 13 Path analysis.	The incidence of LBW were significantly increased with anemia, multiparity, and maternal age <20 or >35 years. In the other hand, the incidence of LBW was significantly decreased with good maternal nutritional status, maternal education ≥high school, and wide birth space.	3

Continue from Table 1

Author (year)	Location	Population	Type of study	Statistical method	Result	Quality assessment
Wulandari *et al.* (2022)	34 provinces in Indonesia	Data from 2017 IDHS. By using sample stratification and multistage random sampling, there were 1,741 women aged 15–49 who gave birth in 5 years prior to the survey as respondents.	Cross-sectional study design.	Software: SPSS 22.0 Chi-Square, Binary logistic regression.	The significant predictors of LBW infants in Indonesia were ANC visits, maternal educational level, age group, and maternal wealth status.	3

AFM: Age at First Marriage ; ANC:Antenatal Care; AUC:Area Under the Curve; BMI: Body Mass Index; GWG: Gestational Weight Gain; IDHS: Indonesian Demographic and Health Survey; LBW: Low Birth Weight; MUAC: Mid Upper Arm Circumference; PAR: Population Attributable Risks; ROC: Receiving Operating Characteristics; SGA: Small for Gestational Age; SUMMIT: Supplementation with Multiple Micronutrient Intervention Trial; VLBW: Very Low Birth Weight

or younger AFM (<19 years old), those from low-income households appeared to be more likely to experience malnutrition than those from higher-income households (Sebayang *et al.* 2012; Supadmi *et al.* 2020; Okriyanto *et al.* 2022; Wulandari *et al.* 2022).

The present study also revealed that Very Low Birth Weight (VLBW) and neonatal death were strongly influenced by young maternal age (Maulinda *et al.* 2021; Azinar *et al.* 2022). These findings emphasize the importance of supporting family planning services for young people who aspire to be parents. The median AFM is increasing, according to IDHS data from 1991 to 2017. In Indonesia, the median AFM is 21.8 years, implying that about a half of Indonesian women are married before the age of 21 (BKKBN/BPS/Kemenkes/ICF 2018). In some

Table 2. Quality assessment of the articles

References	Quality sssessment[1]					Total
	A Use census or representative probabilistic sample of the target population	P Under than 20% loses	I Adjusted LBW by gestational age or independently examined the IUGR and premature birth	E Having a description of the criteria used to classify the populations	C Having the estimates of the adjusted effect controlling confounded factors	
Sebayang *et al.* (2012)	1	1	1	1	1	4
Anggondowati *et al.* (2017)	1	1	1	1	1	5
Soltani *et al.* (2017)	1	1	1	1	1	5
Paramitasari *et al.* (2018)	1	1	0	1	0	3
Supadmi *et al.* (2020)	1	1	0	1	0	3
Adawiyah *et al.* (2021)	1	1	0	1	0	3
Djokosujono *et al.* (2021)	1	1	0	1	1	4
Maulinda *et al.* (2021)	1	1	0	1	1	4
Aji *et al.* (2022)	1	1	1	1	1	5
Azinar *et al.* (2022)	1	1	0	1	0	3
Okriyanto *et al.* (2022)	1	1	0	1	1	4
Wulandari *et al.* (2022)	1	1	0	1	0	3
Total articles per item	12	12	4	12	6	

[1]A: Use census or representative probabilistic sample of the target population; P: Have under than 20% of participant loses; I: Have an adjusted LBW by gestational age or independently examined the IUGR and prematurity; E have a description of the criteria used to classify the populations; C: Have the estimates of the adjusted effect and controlling confounded factors

regions of Indonesia where the child marriage is the norm, unmarried women as young as 17 are occasionally referred to as "old virgins". This societal perception puts pressure on girls to marry at a young age. To change this perception, it is crucial to develop specialized programs that increase knowledge about prenatal care, delivery strategies, safe pregnancy, early warning signs of pregnancy risks, emergency preparedness, and the significance of secondary and tertiary levels of care to ensure optimal outcomes when complications occurs such as excessive bleeding, high blood temperature, gestational diabetes, etc (Maulinda *et al.* 2021; Okriyanto *et al.* 2022; Wulandari *et al.* 2022).

The present review also highlights another risk factor for LBW, which is nutritional status. Many people believe that pregnant women should eat twice as much as they did before they became pregnant because they have to meet the nutritional requirements of two individuals (mother and fetus) during pregnancy. This assumption is incorrect. According to the Indonesian Dietary Recommendation, pregnant women need more calories up to 180 kcal in the first trimester and 300 kcal in the second to third trimester (Peraturan Menteri Kesehatan Republik Indonesia (PMK RI) 2019).

Measurement of MUAC has been used to predict whether pregnant women are at risk of delivering LBW newborns. If the MUAC is less than 23.5 cm, then the pregnant women are in Chronic Energy Deficiency (CED) and are at risk of delivering LBW infants (Schetter & Tanner 2012). Pre-pregnancy BMI is also critical for monitoring GWG. The Institute of Medicine (IOM) recommends that GWG be based on pre-pregnancy BMI because of the numerous negative consequences of both inadequate and excessive weight gain. Women should strive to gain weight within the recommended guidelines, as this is crucial for fetal growth. Tsai *et al.* (2015) revealed that underweight women should adhere to the upper range of the IOM recommendations to prevent LBW newborns.

Antenatal Care, also known as ANC, is a term for the prenatal health services that mothers receive during their pregnancy and are provided by health professionals such as physicians, midwives, and nurses.

Antenatal records during ANC visits are challenging based on the previous research (Anggraini *et al.* 2018; Anggraini *et al.* 2019), and so is ANC coverage in some parts of Indonesia. According to the previous research, the lowest distribution of four ANC visits as a minimum standard was in the eastern region of Indonesia. The percentage was concentrated in the Java-Bali region, followed by the western region. A study conducted in East Nusa Tenggara, Indonesia, showed that pregnant women chose not to receive standard ANC, continued to work at home, and followed several food restrictions due to the cultural practices or "traditional pregnancy care" in order to ensure a smooth delivery (Anggrahini *et al.* 2020).

Third trimester weight also affects the incidence of LBW. Pregnant women in rural areas usually attend ANC at the third trimester (Adawiyah *et al.* 2021; Djokosujono *et al.* 2021). Therefore, early weight at the third trimester is another risk factor for LBW in Indonesia, as rapid gestational weight gain still occurs during this period, so nutrition programs canstill be implemented to address LBW. The cut-off point for weight in the third trimester is between 59.8 kg and 60.5 kg (Adawiyah *et al.* 2021; Djokosujono *et al.* 2021).

In addition, LBW was highly correlated with birth interval (Sebayang *et al.* 2012; Wulandari *et al.* 2022). Mothers who gave birth within 24 months or less were more likely to deliver LBW infants. Nutritional deprivation after the second or third child may increase the likelihood of LBW and SGA (Sebayang *et al.* 2012).

Other factors associated with LBW were twin birth, parity, and pregnancy complications. Twin pregnancy is the most risky variable for LBW and poses a higher chance for infants to develop LBW compared to singleton pregnancies (Okriyanto *et al.* 2022; Wulandari *et al.* 2022). This review recommends that pregnant women with a family history of twin births should monitor their health during pregnancy by attending regular ANC apppointments.

Parity is also associated with the incidence of LBW. Parity has been described as the number of live births. Compared to parity 1 or >3, parity 2 or 3 decreased the probability of LBW incidence (Paramitasari *et al.* 2018). In line with the study by Putri *et al.* (2017), pregnant women with parity >2 had a 12.3 times higher probability of delivering LBW infants. Parity

was discovered to be a high risk factor for LBW, IUGR, prematurity, and neonatal mortality. High parity in the mother can cause a deterioration of the elasticity of the tissues that have been repeatedly stretched by pregnancy, so that it will cause the abnormal growth of the placenta and also the fetus, ultimately causing the incidence of LBW (Putri *et al.* 2017).

Furthermore, another factor influencing the incidence of LBW newborns is iron supplementation. Iron supplementation during pregnancy is associated with an increase in infant birth weight, and significantly affects the incidence of LBW (Shi *et al.* 2021; Okriyanto *et al.* 2022). Iron is needed to prevent hemorrhage during childbirth and also to prevent complications during pregnancy. In addition, it is also needed for the production of Hemoglobin. During childbirth, the uterine contractions are stronger or more intense to deliver a baby. Hemoglobin, which transports oxygen and other nutrients, decreases in anemic pregnant women. Meanwhile, blood-supplied oxygen and energy are needed to make the uterine contractions. As the supply of these needs is getting smaller, the capacity to perform contraction is decreasing, causing hemorrhage (Watkins & Stem 2020).

The strengths of this review are that we used a comprehensive search strategy to maximize the identification of all relevant literature. This review also strengthens other studies on the predictors of LBW in Indonesia. Several articles reviewed in this study used the same data with different inclusion criteria, but resulted in the similar risk factors of LBW. The limitation of this review is the limited number of case-control and cohort studies among the reviewed articles.

CONCLUSION

This study discovered that the incidence of LBW newborns was significantly correlated with several maternal risk factors, such as maternal education, household wealth, nutritional status, age, pregnancy complications, marital age, ANC visits, third trimester weight, twin birth, birth interval, parity, iron supplementation, and anemia status. Most of these risk factors are preventable. Thus, the incidence of LBW can be reduced through interventions that target these risk factors.

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DECLARATION OF INTERESTS

The authors declare that they have no conflicts of interest.

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Validation of a Questionnaire on Knowledge and Barriers of Breast Milk Expression among Mothers of Premature Infants

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ABSTRACT

This study aimed to develop and validate a Malay language questionnaire to assess mothers' knowledge in providing breast milk for premature infants, and barriers to breast milk expression while the infants are in the Neonatal Intensive Care Unit (NICU). Two tertiary hospitals in Kelantan, Malaysia participated in this cross-sectional study. Relevant items of knowledge and barriers were identified through a literature search, clinical observations, and expert opinion. Ten breastfeeding experts validated the content of the knowledge and barriers to breast milk expression questionnaire.The effectiveness of the questionnaires was tested for face validity among ten mothers, followed by reliability tests comprising 50 mothers who gave birth prematurely. The 20 knowledge items and 16 barrier items have an Item-level Content Validity Index (I-CVI) of 0.99, indicating good relevance of the knowledge and barrier items. The knowledge and barrier questionnaires had Item-level Face Validity Indexes (I-FVIs) of 1.00 and 0.99, respectively, suggesting clear and comprehensible items. The questionnaires obtained a Cronbach alpha score of 0.726 for knowledge and 0.736 for barriers, showing that they are reliable tools for assessing knowledge and breast milk expression barriers. The validity and reliability of the newly developed Malay version of the questionnaire have been established for evaluating breastfeeding knowledge and barriers to expressing breast milk among mothers with premature infants.

Keywords: breast milk expression, content validity, face validity, premature infants, questionnaire

INTRODUCTION

Infants delivered before 37 completed weeks of gestation are considered premature and require close monitoring and intensive care (World Health Organization (WHO) 2018). The estimated worldwide premature birth rate for 2014 was 10.6%, or roughly 14.8 million live preterm births (Chawanpaiboon *et al.* 2019). Premature birth rates in Malaysia were 6.63% in 2020, with *Orang Asli*, Indian, and women over 40 having the highest rates (Jeganathan & Karalasingam 2021).

Infants born prematurely have a variety of nutritional and immune protection needs. Breast milk from preterm mothers has higher protein and bioactive molecules levels than milk from term mothers (Underwood 2013). Therefore, the American Academy of Paediatrics encourages all premature neonates to be fed with breast milk. If the mother's milk supply is insufficient, pasteurised donor milk should be supplemented instead of premature infant formula (Eidelman *et al.* 2012).

Even with these benefits, premature babies have lower breastfeeding rates than term newborns. This is supported by a study conducted in Pennsylvania which revealed that the proportion of late preterm infants who were breastfed at one month was 63.8%, as opposed to term newborns had a breastfeeding rate of 72.6% and post-term infants had a rate of 76.5% (Hackman *et al.* 2016). A study in Indonesia also found that children with normal birth weight

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were more likely to be breastfed than those with low birth weight (Prasetyo *et al.* 2023). Another study found that, 52% of Malaysian premature infants were exclusively breastfed at discharge, compared to 32% of premature UK infants (Hamid *et al.* 2021).

Having their infants admitted to the NICU for an extended period, i.e., weeks or months, can be stressful for the mothers of premature infants (Ong *et al.* 2019). NICU admission of a premature neonate shortly following delivery results in separation from the mother, and it is necessary to practice Express Breast Milk (EBM) because breast milk is often regarded as the optimal dietary choice for premature newborns (Namusoke *et al.* 2021). In addition, due to immaturity, poor sucking of the infants and respiratory support received by the infant impede the direct breastfeeding. Therefore, before the newborns can be nursed directly, the process of expressing breast milk is necessary for a duration of many weeks (Heller *et al.* 2021).

Besides that, premature newborns typically exhibit insufficient weight or compromised health conditions that hinder their ability to engage in direct breastfeeding. Thus, it is necessary to initiate milk expression to maintain the mother's milk supply. Consequently, preterm mothers face physical and psychological obstacles, which may negatively impact breastfeeding (Hahn-Holbrook 2018).

Mothers' most common reasons for stopping breastfeeding early for late premature infants admitted to the NICU were not having enough milk or breastfeeding challenges (Kair & Colaizy 2016). Evidence found that knowledge is one factor that can be altered to increase exclusive breastfeeding practices (Che'Muda *et al.* 2016). A study conducted in Poland found that exclusive breastfeeding mothers had a higher mean breastfeeding knowledge score than non-exclusive breastfeeding mothers (Zielinska *et al.* 2017).

Thus, having a valid and reliable questionnaire suited to the local culture is crucial to evaluate the knowledge on feeding breast milk and barriers to breast milk expression among mothers with premature infants. Up until now, there are limited assessment tools for this purpose. Therefore, a Malay language version of a questionnaire to evaluate the understanding of mothers with premature infants regarding knowledge of feeding breast milk and barriers to breast milk expression needs to be developed and validated.

METHODS

Design, location, and time

The cross-sectional research was carried out at two tertiary hospitals in Kelantan, Malaysia. Data was collected from September to October 2021 for content and face validity. Reliability testing was conducted from November to December 2021. The ethical endorsement was given by the Human Research Ethics Committee of Universiti Sains Malaysia (USM/JEPeM/20120677) on the 18th April 2021 and the Ministry of Health Malaysia Medical Research and Ethics Committee (NMRR-20-2817-57640 [IIR]) on 18 May 2021.

Sampling

The study involved two phases, namely the development of the questionnaire, followed by the validation of the developed questionnaire. The validation process involved content validity, face validity, and reliability testing. During the development phase, multiple methods were employed to create a new and comprehensive instrument. Information regarding the knowledge on breastfeeding and the barriers to expression among women with premature infants was identified, created, organized, and documented into a useful tool. Literature searches, professional expert opinions, and clinical observations constituted most of the information sources. The items knowledge of feeding breast milk and barriers to breast milk expression among premature infants were developed using reviews of previous literature. The initial/pre-validated questionnaire consisted of 21 items regarding knowledge of feeding breast milk to premature infants. The questionnaire was divided into 3 sections/domains; 1) general knowledge on feeding breast milk to premature infants (7 items) (Bertino *et al.* 2012; Eidelman *et al.* 2012; Underwood 2013); 2) knowledge on breastmilk expression and transportation to NICU (10 items) (Che'Muda *et al.* 2016; Parker *et al.* 2012; The Royal Women's Hospital 2015); 3) knowledge of breast milk storage for ill infants (4 items) (Che'Muda *et al.* 2016; WHO 2006). Meanwhile, the initial/pre-validated questionnaire on barriers

to breast milk expression consisted of 16 items (Alves *et al.* 2013; Gianni *et al.* 2018; Sisk *et al.* 2010).

The initial developed and drafted questionnaire was based on literature reviews. Then, three meetings were scheduled with a panel of experts, consisting of a lactation consultant, neonatologist, and family medicine specialist, to collect feedback, identify other significant information that was required but missing, and eliminate irrelevant information based on their expertise in instrument development. The collected remarks and responses were used to revise the questionnaire. The original questionnaire was created in Malay and discussed with the experts. Then, a final questionnaire draft in the source language (Malay) was produced for questionnaire validation. The questionnaire's final draft comprised of 20 items on the knowledge of feeding breast milk to premature infants and 16 items on barriers to breast milk expression.

Data collection

As part of the validation procedure, the content validity, face validity, and reliability (internal consistency) of the questionnaire were assessed by a panel of experts. The verification process revealed that each item was relevant and accurately represented a particular domain. The items and domain of knowledge and attitude part were explained above.

To verify the content validity of the questionnaire, ten panels consisting of two lactation consultants, two obstetrics and gynaecology specialists, two neonatologists, two family medicine specialists, and two lactation nurses were invited to validate the content of the questionnaire. Validators who agreed to rate the survey's items received the questionnaires through email. The validators weren't from the same hospital or institution and were instructed to rate the questionnaire based on their expertise individually.

The range of scores for each domain was 1 (irrelevant) to 4 (highly relevant). Following the scoring given by validators, the scores were categorized and classified. Items with a score of 3 or 4 were categorized as 1 (relevant), whereas those with a score of 1 or 2 were categorized as 0 (not relevant). Following the initial meeting, items were modified in accordance with the panel's advice.

Two different types of Content Validity Index (CVI), CVI for Item-level Content Validity Index (I-CVI) and CVI for Scale-level Content Validity Index (S-CVI) were identified. Two methods were employed for calculating S-CVI. The first method was scale-level content validity index, averaging calculation method (S-CVI/ Ave). The S-CVI/Ave was measured by obtained I-CVI values through formula (1) then using a formula (2), the sum of all I-CVI values was divided by the number of items.

(1) I-CVI = (agreed item) / (number of rater)

(2) S-CVI/Ave = (summation all I-CVI) / (number of item)

The second method of S-CVI obtained the average score of each rater by using universal agreement calculation method (S-CVI/UA). Score '1' was assigned to the item that achieved 100% experts in agreement. To obtain the value of S-CVI/ UA of a specific domain, the total number of items with 100% in agreement was divided by the total number of items in that domain (Yusoff 2019a).

Item-level Content Validity Index (I-CVI), Scale-level Content Validity Index (S-CVI), Scale-level Content Validity Index, Averaging Calculation method (S-CVI/Ave and Universal Agreement calculation method (S-CVI/UA)) were manually calculated. The evaluation of each item individually and its average were considered during the data presentation.

Then, the face validity process was conducted. The face validation test evaluates the clarity and comprehension of each item. The self-administered questionnaire was administered to ten mothers who delivered premature infants and whose babies were admitted to the NICU. The mothers were selected conveniently, and each mother had to provide a written consent before the evaluation.

The mothers were asked to rate each item on the knowledge and barrier questionnaire from 1 (unclear and incomprehensible) to 4 (item is very clear and comprehensible). Following a review of the responses, the ratings of 1 and 2 were reclassified as 0 (unclear and incomprehensible), while the ratings of 3 and 4 were reclassified as 1 (clear and comprehensible) (Yusoff 2019b). The Face Validity Index (FVI) was computed using the raw scores entered in Microsoft Excel. There are two forms of FVI: the Item-level Face Validity Index (I-FVI) and the

Scale-level Face Validity Index (S-FVI). S-FVI is calculated using two different methods: the average of the I-FVI scores for each item on the scale (S-FVI/Ave), and the percentage of items on the scale that receive a score of 3 or 4 on the clarity and comprehension scale from all raters (S-FVI/UA). The item received a score of "1" for Universal Agreement (UA) if all raters agreed on it at 100%; otherwise, a score of "0" was assigned (Yusoff 2019b).

The following formulas are used to determine FVI:

(3) I-FVI (item-level face validity index) = agreed item/number of rater

(4) S-FVI/Ave (scale-level face validity index based on the average method) = (sum of I-FVI scores)/(number of item)

(5) S-FVI/UA(scale-level face validity index based on the universal agreement method) = sum of UA scores/number of item

Following this, improvements were made to the questionnaire. The items were revised to construct a questionnaire that is easy to understand. The mothers were prompted to submit written feedback upon completion of the questionnaire to contribute to the refinement of the items' clarity. However, there was no feedback received from the mothers.

Data analysis

Data analysis for the second phase involved validating the developed questionnaire consisting of content validity, face validity, and reliability testing. It started with content validity measurement. The raw ratings of content validity from 10 panels were collected, and the data was then put into Microsoft Excel to be analyzed. A score of "1" indicating the items were relevant and a score of "0" indicating the items were irrelevant. The agreement must reach 80% or higher for a tool to be accepted for content validity (Davis 1992).

For face validity, the raw scores of 10 mothers were inserted into Microsoft Excel to calculate the Item-level Face Validity Index (I-FVI); "1" indicates that the items were clear and comprehensible and "0" indicates that the items were unclear and incomprehensible. An FVI of 0.8 or higher was recommended (Pelet *et al.* 2012).

Then, reliability testing was performed to evaluate the questionnaires' internal consistency. It was conducted by giving a final set of the questionnaires to 50 mothers who delivered premature infants at two tertiary hospitals in Kelantan. The mothers were conveniently selected.

RESULTS AND DISCUSSION

Content validity

The result of the content validity reveals that the overall index is higher than 0.80. The Universal Agreement Index (S-CVI/UA) was 0.9 for knowledge of feeding breast milk to preterm newborns and 0.93 for barriers to breastmilk expression. Apart from that, an Average Index (S-CVI/Ave) of 0.99 was found for both knowledge and barriers to expressing while newborn were in the NICU (refer to Table 1 and Table 2). In the present study, the overall CVI for knowledge on feeding breast milk to premature infants and barriers to breast milk expression was higher than 0.95. This means that the 20 items used to measure knowledge and the 16 items used to measure barriers to breast milk expression were relevant. A content validity index of 0.8 or higher is considered appropriate and applicable for a new instrument (Davis 1992; Polit *et al.* 2007). The content validation result shows the language is clear, appropriate, and culturally valid for the intended population, i.e. the Kelantanese population. Suitable and valid instruments or questionnaires necessitate a number of essential steps. The instrument must be adaptable to diverse populations with diverse linguistic and cultural backgrounds (Lau *et al.* 2018).

This new validated questionnaire was designed to accommodate the local culture norm, provide a more accurate measurement of breastfeeding knowledge, and identify the obstacles to perform expression by premature infants' mothers. The newly developed questionnaire evaluates the general breastfeeding knowledge of premature infants, including the duration of the mother's need to supply exclusive breast milk feeding and the advantages of breast milk to premature infants. Apart from that, knowledge of breastmilk expression, breast milk transportation to NICU, and storage of breast milk in ill infants was evaluated. This fundamental knowledge is crucial to ensure the success of exclusive breastfeeding practices among premature infants. The newly developed

Table 1. Ratings on the knowledge of feeding breast milk to premature infants by the 10 experts

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	Expert in agreement	I-CVI	UA
K1	1	1	1	1	1	1	1	1	1	1	10	1	1
K2	1	1	1	1	1	1	1	1	1	1	10	1	1
K3	1	1	1	1	1	1	1	1	1	1	10	1	1
K4	1	1	1	1	1	1	1	1	1	1	10	1	1
K5	1	1	1	1	1	1	1	1	1	1	10	1	1
K6	1	1	1	1	1	1	1	1	1	1	10	1	1
K7	1	1	1	1	1	1	1	1	1	1	10	1	1
K8	1	1	1	1	0	1	1	1	1	1	9	0.9	0
K9	1	1	1	1	1	1	1	1	1	1	10	1	1
K10	1	1	1	1	1	1	1	1	1	1	10	1	1
K11	1	1	1	1	1	1	1	1	1	1	10	1	1
K12	1	1	1	1	1	1	0	1	1	1	9	0.9	0
K13	1	1	1	1	1	1	1	1	1	1	10	1	1
K14	1	1	1	1	1	1	1	1	1	1	10	1	1
K15	1	1	1	1	1	1	1	1	1	1	10	1	1
K16	1	1	1	1	1	1	1	1	1	1	10	1	1
K17	1	1	1	1	1	1	1	1	1	1	10	1	1
K18	1	1	1	1	1	1	1	1	1	1	10	1	1
K19	1	1	1	1	1	1	1	1	1	1	10	1	1
K20	1	1	1	1	1	1	1	1	1	1	10	1	1
											S-CVI/Ave	0.99	
	1	1	1	1	0.95	1	0.95	1	1	1	S-CVI/UA		0.9
	Average proportion of items judged as relevance across the 10 experts=0.99												

I-CVI: Item-level Content Validity Index; UA: Universal Agreement calculation method; Ave: Averaging calculation method; S-CVI/UA: Scale-level Content Validity Index, Universal Agreement calculation method; S-CVI/Ave: Scale-level Content Validity Index, Averaging calculation method

questionnaire also assessed barriers to breast milk expression while infants were admitted to NICU. The barrier factors for the mother to initiate and practice breast milk expression need to be investigated as they will be a contributing factor for women not to breastfeed in the future exclusively.

Face validity

Similar to the calculation of content validity, the calculation of face validity includes the Item-level Face Validity Index (I-FVI), the Scale-level Face Validity Index (S-FVI), which comprised the Universal Agreement Face Validity Index (S-FVI/UA) and the Averaging Index (S-FVI/Ave) among 10 respondents. The Face Validity Index of Universal Agreement (S-FVI/UA) for knowledge is 1.00 and the barrier of feeding breast milk to premature infants is 0.94. The results also revealed Average Knowledge (S-FVI/Ave) of 1.00 and an average barrier of feeding breast milk to premature infants (S-FVI/Ave) is 0.99 (Table 3).

In this study, the high face validity score in terms of clarity and comprehensibility shows a good response process (DeVon *et al.* 2007). However, one respondent thought that item B2 on "Feelings of stress with premature delivery prevented me from expressing breast milk" was unclear and understandable. The other nine respondents thought that all the items were clear and understandable. This item is important to be evaluated because a study found that women did not express breast milk regularly as they should have because they were not ready for a premature birth and were worried about their baby's health, job, and money (Sisk *et al.* 2010). Thus, no items were removed during the validation procedure.

Internal consistency

The respondents' Mean (SD) age was 31.50 (SD 5.91) years. About half of the respondents

Table 2. Ratings on the barrier of feeding breast milk to premature infants by the 10 experts

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	Expert in agreement	I-CVI	UA
B1	1	1	1	1	1	1	1	1	1	1	10	1	1
B2	1	1	1	1	1	1	0	1	1	1	9	0.9	0
B3	1	1	1	1	1	1	1	1	1	1	10	1	1
B4	1	1	1	1	1	1	1	1	1	1	10	1	1
B5	1	1	1	1	1	1	1	1	1	1	10	1	1
B6	1	1	1	1	1	1	1	1	1	1	10	1	1
B7	1	1	1	1	1	1	1	1	1	1	10	1	1
B8	1	1	1	1	0	1	1	1	1	1	9	1	1
B9	1	1	1	1	1	1	1	1	1	1	10	1	1
B10	1	1	1	1	1	1	1	1	1	1	10	1	1
K11	1	1	1	1	1	1	1	1	1	1	10	1	1
B12	1	1	1	1	1	1	0	1	1	1	9	1	1
B13	1	1	1	1	1	1	1	1	1	1	10	1	1
B14	1	1	1	1	1	1	1	1	1	1	10	1	1
B15	1	1	1	1	1	1	1	1	1	1	10	1	1
B16	1	1	1	1	1	1	1	1	1	1	10	1	1
B17	1	1	1	1	1	1	1	1	1	1	10	1	1
B18	1	1	1	1	1	1	1	1	1	1	10	1	1
B19	1	1	1	1	1	1	1	1	1	1	10	1	1
B20	1	1	1	1	1	1	1	1	1	1	10	1	1
											S-CVI/Ave	0.99	
	1	1	1	1	0.95	1	0.95	1	1	1	S-CVI/UA		0.93
	Average proportion of items judged as relevance across the 10 experts=0.99												

I-CVI: Item-level Content Validity Index; UA: Universal Agreement calculation method; Ave: Averaging calculation method; S-CVI/UA: Scale-level Content Validity Index, Universal Agreement calculation method; S-CVI/Ave: Scale-level Content Validity Index, Averaging calculation method

had completed secondary school (42%) and post-secondary education (58%), and 48% of them were employed.

The reliability analysis based on the Cronbach's alpha verified that the final 20 items on knowledge and 16 items on barriers to breast milk expression shown a high degree of internal consistency with a score of 0.726 for knowledge and 0.736 for barriers to breast milk expression

Table 3. Face validity index for knowledge and barriers to feeding breast milk to premature infants by 10 respondents

Section	No of item	S-FVI/Ave	S-FVI/UA
Knowledge	20	1	1
Barrier	16	0.99	0.94

S-FVI: Scale-level Face Validity Index; S-FVI/UA: Universal Agreement calculation method; S-FVI/Ave: Averaging calculation method across 10 respondents

among mothers with premature infants. The reliability analysis programme in SPSS was used to determine the questionnaire's internal consistency (Streiner *et al.* 2015).

A questionnaire's reliability is attributed to its validity and its stability is depicted through the consistency of the received responses. Internal consistency is used to determine the degree of homogeneity among questionnaire items. The Cronbach alpha coefficient is the most commonly used method for determining internal consistency (Bolarinwa 2015). A value between 0.7 and 0.9 suggests that the internal consistency is high, while values between 0.6 and 0.7 are considered satisfactory (Streiner *et al.* 2015). The Cronbach's alpha values of the final 20 items for knowledge and 16 items on barriers to breast milk expression in this study are 0.726 and 0.736, respectively. These values are high, hence signifying that the instrument used, i.e., the newly developed questionnaire, is reliable for

assessing the knowledge on feeding breast milk and barriers to perform expression among these mothers. Table 4 and Table 5 summarize of the final domains and component items.

Table 4. Final items of knowledge on feeding breast milk to premature infants by three components

Item		Component
K1	Premature infants should receive breast milk (*Bayi pramatang perlu diberikan susu ibu*)	General breastfeeding knowledge for premature infants (K1–K6)
K2	Premature infants require special formula milk though expressed breast milk was prepared for the infant (*Bayi pramatang memerlukan susu formula khas walaupun susu ibu yang diperah disediakan untuk bayi*)	
K3	Premature infants should receive other drinks other than breast milk such as plain water (*Bayi pramatang memerlukan minuman lain selain daripada susu ibu seperti air masak*)	
K4	Premature infants should receive exclusive breast milk for the first 6 months (*Bayi pramatang perlu diberikan susu ibu sahaja selama 6 bulan pertama*)	
K5	Breast milk reduces the risks of necrotizing enterocolitis in preterm infants (*Susu ibu mengurangkan risiko radang pada usus bayi pramatang*)	
K6	Breast milk reduces the risks of meningitis in preterm infants (*Susu ibu dapat mengurangkan risiko jangkitan kuman pada selaput otak bayi pramatang*)	
K7	Mothers who are not with their infants should start breast milk expression within the first 6 hours after birth (*Ibu yang tidak bersama bayinya perlu memulakan pemerahan susu ibu dalam tempoh 6 jam pertama selepas kelahiran*)	Knowledge of breastmilk expression and transportation to Neonatal Intensive Care Unit (K7–K16)
K8	Breast milk expression needs to be done every 3 hours if the premature baby is away from the mother (*Ibu yang tidak bersama bayinya, perlu memerah susu setiap 3 jam*)	
K9	Moist heating and massage before breast milk expression can promote milk secretion (*Demahan panas dan urutan sebelum pemerahan susu dapat merangsang pengeluaran susu*)	
K10	Expressed breast milk needs clear labeling of name of infant, date, and time of expression (*Susu perahan perlu dilabel dengan nama bayi, tarikh dan masa susu itu diperah*)	
K11	Breast milk expression can be done simultaneously on both sides of the breast *(Perahan susu boleh dilakukan serentak pada kedua-dua belah payudara)*	
K12	Expressed breast milk may be mixed with previously expressed milk (*Susu perahan boleh dicampur dengan susu perahan sebelumnya*)	
K13	The leftover expressed breast milk that has been used may be stored again (*Lebihan susu perahan yang telah diberikan kepada bayi boleh disimpan semula*)	
K14	Expressed breast milk may be warmed on fire (*Susu perahan boleh dipanaskan di atas api*)	
K15	Expressed breast milk may be warmed in a microwave (*Susu perahan boleh dipanaskan dalam ketuhar gelombang mikro*)	
K16	Expressed breast milk transported to the hospital must be kept chilled in a cool box with ice or cooler pack (*Susu perahan yang dibawa ke hospital mesti disimpan di dalam kotak ais yang berisi ais atau pek sejuk*)	
K17	Expressed breast milk may be stored for 4 hours at room temperature (*Susu perahan boleh disimpan sehingga 4 jam pada suhu bilik*)	Knowledge of breastmilk storage for ill infants (K17–K20)
K18	Expressed breast milk may be stored for 48 in a lower part of a refrigerator (*Susu perahan boleh disimpan sehingga 48 jam di bahagian bawah bagi peti sejuk dua pintu*)	
K19	Expressed breast milk may be stored for 2 weeks in a freezer of a 1-door refrigerator (*Susu perahan boleh disimpan sehingga 2 minggu di bahagian sejuk beku dalam peti sejuk 1 pintu*)	
K20	Expressed breast milk may be stored for 3 months in a freezer of a 2-door refrigerator (*Susu perahan boleh disimpan sehingga 3 bulan di bahagian sejuk beku dalam peti sejuk 2 pintu*)	

Table 5. Items of barrier to breast milk expression domain by 1 component

Item		Component
B1	I have a problem to express breast milk because I am not prepared for premature delivery (*Saya mempunyai masalah untuk melakukan perahan susu ibu kerana tidak bersedia dengan kelahiran bayi pramatang*)	Barriers to breastmilk expression while infants in Neonatal Intensive Care Unit / Nursery
B2	Feelings of stress with premature delivery hindered me from expressing breast milk (*Perasaan stres dengan kelahiran bayi pramatang mengganggu saya untuk memerah susu*)	
B3	I feel uncomfortable while exressing breast milk (*Saya berasa tidak selesa semasa memerah susu*)	
B4	I experience a lack of privacy while expressing milk (*Saya mengalami kekurangan privasi semasa memerah susu*)	
B5	I feel embarrassed to express milk using a breast pump (*Saya berasa malu untuk memerah susu menggunakan pam susu*)	
B6	I feel the act of breast milk expression is tiring (*Saya merasakan perbuatan memerah susu adalah memenatkan*)	
B7	My body feels too tired to express breast milk (*Keadaan badan yang keletihan mengganggu saya untuk memerah susu*)	
B8	My husband is less supportive of me regarding breast milk expression (*Suami kurang menyokong saya untuk memerah susu*)	
B9	The family is less supportive of me regarding breast milk expression (*Keluarga kurang menyokong saya untuk memerah susu*)	
B10	I felt the hospital staff was less supportive of me about breast milk expression (*Saya merasakan kakitangan hospital kurang menyokong saya untuk memerah susu*)	
B11	I don't have enough time to express breast milk (*Saya tidak mempunyai masa yang cukup untuk memerah susu*)	
B12	I feel that breast milk expression is a waste of time (*Saya berasa membazir masa untuk memerah susu*)	
B13	Expressing breast milk causes pain in my breasts. (*Memerah susu menyebabkan saya berasa sakit pada payudara*)	
B14	Inadequate milk supply interrupted my breast milk expression activity (*Pengeluaran susu yang sedikit mengganggu saya untuk memerah susu*)	
B15	I do not have a breast pump at home (*Saya tidak mempunyai pam susu di rumah*)	
B16	The difficulty in delivering the expressed milk from home to the hospital discourages me from expressing breast milk (*Halangan untuk menghantar susu ke hospital mengganggu saya untuk memerah susu*)	

CONCLUSION

This newly developed and validated questionnaire in Malay language to assess the knowledge of feeding breast milk to premature infants and the barriers to expressing breast milk among mothers in Kelantan has been validated and have shown to be a reliable instrument. This tool is practical simple to comprehend, and applicable to various subject populations with minimal modification. The barrier to breast milk expression items can be revised and expanded by identifying additional factors that may impede mothers from expressing their milk through qualitative research.

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DECLARATION OF INTERESTS

The authors have no conflict of interest.

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Geophagia in Nigeria: Perceptions and Practices of Pregnant Mothers versus Possible Health Outcomes

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ABSTRACT

This study aimed at ascertaining the perceptions and practices of pregnant mothers on geophagia, as well as highlighting possible health outcomes. For the cross-sectional survey, a structured questionnaire was designed, content-validated by experts, pre-tested and used for data collection. The questionnaires were administered to 200 pregnant mothers at health care facilities in southern Nigeria (particularly in Calabar and Onitsha), who consented to be part of the study. The findings of this study show that about 75% of the pregnant mothers admitted to consuming edible clays both during and after pregnancy with 60% of them stating that it was a safe practice during pregnancy. Also, the results show that income level and educational attainment significantly ($p<0.05$) influenced the perception and practices of the respondents regarding geophagia. Of the 2 edible clays explored in this study, kaolin clay was more popularly consumed than bentonite clay. With regards to respondents' health status, none of them admitted to developing anaemia or any chronic disease during pregnancy. In conclusion, edible clays are still commonly consumed by women in Southern Nigeria, irrespective of age and exposure. Scientific reports show that these clays contain appreciable amounts of certain anti-nutrients and heavy metals, hence it is necessary to create awareness on the possible dangers related to their increased consumption, particularly during pregnancy.

Keywords: edible clays, geophagia, health outcomes, pica, pregnancy

INTRODUCTION

Pregnancy is a sensitive physiological state with its peculiarities. During pregnancy, pica which is the craving for non-food substances such as ice, soil, soft stones, commonly occurs (Myaruhucha 2009; Johnson 2017). Geophagia is a common form of pica; it has to do with the ingestion of soil, earth and clay substances (Taiye *et al.* 2013). Edible clay is commonly known as calabash chalk. Calabash chalk is one of such geographic material prevalently consumed in many countries. The health and wellbeing of both mother and child can be at risk during gestation, if proper attention is not given to adequate nutrition. The current focus of research is on the complex relationships between food intake and disease, consumer knowledge and dietary patterns, economic status, and consumer choices relating to various foods and non-food substances, including organic, genetically modified, and conventional ones. This is because healthy diets play a major role in preventing diseases and maintaining health (Wardle 2000). Furthermore, the increase in the prevalence of chronic diseases and maternal mortality, is also a growing cause for concern. According to Onyenweaku *et al.* (2019), dietary modifications in addition to synthesized drugs, is now being employed while managing and treating illnesses linked to food. People are becoming increasingly aware of the importance of being mindful of what they consume, especially as it concerns those in the vulnerable groups such as infants, pregnant mothers and the elderly.

Geophagic practices appear to be as old as human-kind and are more prevalent in some places than others (Odangowei & Okiemute 2015). Geophagia was seen as a superstitious practice during the 16th and 18th centuries, which is why efforts were made to both avoid it and offer treatment to those who practiced it (Ekosse & Jumbam 2010). Some women who practice geophagia believe that it enhances beauty, and it helps pregnant women manage morning sickness or even boosts fertility (Mogongoa *et al.* 2011).

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Generally, there are three main hypotheses about the physiological reasons of pica, which include starvation, a lack of certain micronutrients, and defense against infections and poisons (Odangowei & Okiemute 2015). Pregnant women in Africa believe that consuming soil will aid in a smooth delivery and improve the baby's dark skin pigmentation. According to George and Ndip (2011), Some explanations offered by expectant mothers include: basic cravings based on their texture and scent; the ability of soils to lessen morning sickness symptoms; hunger pangs; and the notion that soils can supply certain micronutrients crucial for the developing fetus. Nevertheless, existing evidence suggests that geophagic practice is not exclusive to the impoverished; it transcends all racial, religious, socioeconomic and racial divides (Abrahams 2002; Onyenweaku 2023).

In general, geophagia is regarded as a pregnancy-related custom, cultural practice, or religious practice (Woywodt & Kiss 1999), or as a treatment for illness (Dominy *et al.* 2004; Onyenweaku 2023). Many people who practice geophagia do so because, culturally speaking, they watched their mothers or close relatives eat clays. These clays contain chemical elements some of which are essential to human health, while others may be toxic or even lethal, depending on the individual dosage (Gomes & Silva 2007). For many centuries, anemia, or low iron levels, has been associated with geophagia (Odangowei & Okiemute 2015). Recently, scientists and medical professionals have validated this long-held finding (Odangowei & Okiemute 2015). The focus has been on lead's toxicity when it comes to chemical elements found in geophagic materials. Well known as a neurotoxin, lead is especially dangerous for young people's developing brains and nervous systems. It is a thing of concern that urban soils contain substantial amounts of Lead, Calcium even Zinc. The internal accumulation of soils (clay) in the body may cause not only abdominal pain and constipation, but may also lead to obstruction and perforation of the large intestine (Bateson & Lebroy 1978; Odangowei & Okiemute 2015). Some cases have been reported in some pregnancies of deaths and dysfunctional labour brought on by internal soil buildup (Horner *et al.* 1991; Odangowei & Okiemute 2015).

Knowledge/awareness plays a key role in determining people's lifestyle, the choices they make and consequently their health outcomes; thus it is necessary that people are properly aware of the foods they consume and its effect on health (Wardle *et al.* 2000; Nyawo *et al.* 2021). Summarily, the studies report that nutrition knowledge affects people's dietary choices/ patterns in the same way irrespective of their financial levels (Shimokawa 2013). Thus, this study assessed the perceptions and practice of pregnant mothers regarding geophagia and also possible health outcomes as a result of this practice.

METHODS

Design, location, and time

Cross-sectional study design using a convenience sampling method was employed in this research. It was carried out at antenatal clinics in General hospital, Onitsha, Iyi-enu mission hospital, Ogidi, Anambra state and General hospital Calabar, Cross River state. Structured interviews were conducted in April, 2023, using an anonymous, self-structured, closed-ended questionnaire designed specifically for the study. Respondents were approached, then asked to carefully read and comprehend the research objectives before completing the questionnaire. The informed consent attached assured the participants that all information given were to be strictly used for research purposes. Participants' responses were recorded anonymously and kept confidential. Names and/or contact information were not required of participants. Participants voluntarily agreed to take part in this anonymous study by signing the consent forms and proceeding to complete the questionnaire.

Sampling

The study population consisted of 200 pregnant women, who attended antenatal clinics in General hospital, Onitsha, Iyi-enu mission hospital, Ogidi, Anambra state and General hospital Calabar, Cross River state. Convenience and random sampling methods were used to get the study participants. Random sampling (within the study population) of pregnant mothers attending antenatal clinics, was employed to find research subjects, increasing the sample size to 200 individuals overall. The inclusive criteria for the study were healthy, pregnant women while the exclusive criteria were - men, children, and non-pregnant women.

Data collection

A well-structured questionnaire based on the study objectives and literature review was created in order to collect data from the respondents. The questionnaire was content-validated by experts in the field, then pre-tested on 20 persons who were excluded from the main study. The questionnaire's reliability coefficient (Cronbach Alpha) was 0.7. The questionnaire was designed to collect sociodemographic information, participants' perceptions and practices with regards to geophagia, and health status. The Microsoft word document of the questionnaire was prepared then hard copies were printed for circulation.

Pregnant women's practices of eating soil were documented, and their attitudes and beliefs regarding geophagia were investigated through the use of a questionnaire. The questionnaire comprised of three sections. Section A was on background information (socio-demographic variables), Section B was designed to collect data on the respondents' perception and practice of geophagy, while Section C was designed to ascertain the health status of respondents. Duly completed copies of the questionnaire were used for analysis.

The questionnaires were taken by research assistants to the different health facilities where the participants attended antenatal clinic. Some of the respondents were assisted by the research assistants to fill the questionnaires to enhance accuracy and minimize ambiguity in responses. Participation in the study was voluntary.

The study received ethical clearance in February 2023 from the University of Calabar Teaching Hospital's Health & Research Ethics Committee in Cross River State (file reference HREC/021/23).

Data analysis

The statistical package for social sciences (SPSS, version 25.0) was utilized in this study to analyse data. Furthermore, to specify the percentage of answers to each question and the overall distribution in the total score of each questionnaire, descriptive statistics like frequencies, percentages, and charts were employed. Correct responses were scored 1 or 2 points respectively while wrong perceptions were scored zero (0). A total score was recorded for each participant. To look for associations between selected variables, logistic regression analysis and Pearson's Chi square test were also utilized. The selected variables were educational level, income and geophagic perceptions/practices scores, and significance was accepted at $p<0.05$.

RESULTS AND DISCUSSION

Table 1 presents the socio-demographic characteristics of the surveyed population (200 pregnant mothers). Almost 60% of them were aged below 40 years. Majority of them (77.50 %) were married while 6.50% were separated from their spouses. Many of the respondents (72%) had a Tertiary Education and above. In addition, most of the respondents (71%) were working in the Private sector and 51% revealed that their monthly income ranged between ₦50,000.00 and ₦149,000.00 which is between 50USD and 150USD. Out of the 200 respondents in this study, 174 of them lived in 2–6 person households.

Perceptions and practices of respondents regarding geophagia

The responses given by the participants generally indicated good knowledge of the subject – geophagia. The findings on the perceptions and practices on the consumption/use of edible clays by respondents, are presented in Table 2. From the results, only 33% admitted that the consumption of edible clays ("Nzu" and "Ulo") is good for health, but up to 70% reported consuming edible clays. Many of the respondents (60.60%) felt that edible clay consumption is safe during pregnancy, with 83.50% stating that the edible clays do not contain any micronutrients and antioxidants that are useful to the body. Furthermore, 37% of the respondents believe that edible clay consumption helps to relieve morning sickness in early pregnancy, with 54.50% stating that both clays can be used on the face as an anti-ageing mask as well as a cure for acne and pimples. About 77% believed that the consumption of edible clays can neither cause hypertension nor can it lead to a decrease in appetite.

The association of educational attainment on perception and practice of geophagia

Table 3 shows the results of the regression analyses carried out on respondents' perceptions and educational level. The logistic regression model was statistically significant ($p<0.05$),

Table 1. Socio-demographic characteristics of the surveyed population

Variable	n	%
Age group (years)		
18–29	46	23
30–39	70	35
40–49	56	28
50–59	26	13
>60	2	1
Ethnicity		
Igbo	42	21
Hausa	30	15
Yoruba	71	35.50
Others	57	28.50
Marital status		
Single	26	13
Married	155	77.50
Separated	13	6.50
Widow	6	3
Education		
No formal education	3	1.50
Primary	2	1
Secondary	50	25
Tertiary	71	35.50
Post grad education	74	37
Income		
<₦50,000 (50USD)	13	6.50
₦50,000–₦149,000 (50–150USD)	102	51
₦150,000–299,000 (150–300USD)	77	38.50
>₦300,000 naira (300USD)	8	4
Occupation		
Public Sector	43	21.50
Private sector	142	71
Company	13	6.50
Informal	2	1
Household size		
Staying alone	17	8.50
2–3 persons	120	60
4–6 persons	54	27
>6 persons	9	4.50
Total	200	100

₦: Nigerian Naira

as the table illustrates. From the results, that perceptions and practices of the respondents differed significantly according to educational status, hence education significantly ($p<0.05$) affected the respondents' perceptions and practices of geophagia. Similarly, the check for association between income levels and respondents' perception/practice of geophagia also revealed that the respondent's income significantly ($p=0.001$) affected their perception of edible clay consumption.

Health status of respondents

In Table 4, the health status of the respondents showed that none of them reportedly had anemia, while about 33% admitted to having hypertension and 67.40% had been previously diagnosed of diabetes. Generally, up to 65% reported that they developed no serious health issues during pregnancy. Among those who admitted having specific health issues during pregnancy, 12 of them reported that they had abdominal pain during pregnancy. Up to 24 of the pregnant mothers said they had malaria during pregnancy while 8 of them had typhoid fever. With regards to the effect of geophagia on respondents' health, 93.30% reported that they have not observed any negative changes during/after pregnancy due to their consumption of edible clays.

The association between participants' health status and practice of geophagia

Table 5 shows the results of the regression analyses carried out on respondents' geophagic practices and their health status, especially during pregnancy. The logistic regression model showed statistical significance ($p<0.05$), as can be observed in the table. From the results, the consumption of both kaolin clay and bentonite clay significantly affected the participants' history of chronic illnesses, and their experience of ill health during pregnancy. The issue of having health challenges during pregnancy as a result of geophagia was not significantly affected by their consumption of the edible clays. The frequency of consumption of the edible clays did not seem to affect the health status parameters except for history of chronic diseases ($p=0.000$).

Young, educated pregnant mothers made up a larger portion of the study population. Most of the women were well-educated and earned

Table 2. Perceptions and practices of the respondents regarding geophagia

Variable	Sub-variable	n	%
1. Do you think that the consumption of edible clays is good for health health?	No	108	54
	Yes	66	33
	Not sure	26	13
2. Is geophagia safe during pregnancy?	No	47	23.70
	Yes	120	60.60
	Don't know	31	15.70
3. Do edible clays contain micronutrients and antioxidants that are useful to the body?	No	167	83.50
	Yes	18	9
	Don't know	15	7.50
4. Do you think consumption of edible clays can alleviate morning sickness in pregnancy?	No	83	41.50
	Yes	74	37
	Not sure	43	21.50
5. Do you think edible clays be used on the face as anti-ageing mask and for acne/pimples?	No	30	15
	Yes	109	54.50
	Not sure	61	30.50
6. In your opinion, does the consumption of edible clays help in the treatment of poisoning?	No	58	29
	Yes	16	8
	Not sure	126	63
7. Do you think the consumption of edible clays can increase blood pressure?	No	154	77
	Yes	12	6
	Not sure	34	17
8. Does consumption of edible clays decrease one's appetite?	No	156	78
	Yes	7	3.50
	Not sure	37	18.50
9. Do you consume edible clays? (such as kaolin 'nzu' & bentonite 'ulo')	Never	57	28.50
	Sometimes	104	52
	Only during pregnancy	39	19.50
10. How often do you consume edible clays?	Do not consume	57	28.50
	<3 times a week	82	41
	3–6 times a week	49	24.50
11. Do you consume kaolin clay?	Daily	12	6
	Yes	151	75.50
	No	49	24.50
12. Do you consume bentonite clay?	Yes	143	71.50
	No	57	28.50

*1–8 indicate their perceptions while 9–10 indicate the practice of geophagia

Table 3. Association between educational attainment and respondents' perceptions and practice of geophagia

Variable	Education	N	Mean	SEM	*p*-value
Practice	No formal education	3	6.00	0.00	
	Primary	2	5.00	0.00	
	Secondary	50	4.98	0.13	0.001
	Tertiary	71	4.59	0.07	
	PGE	74	5.12	0.10	
Perception	No formal education	3	0.00	0.00	
	Primary	2	2.00	0.00	
	Secondary	50	5.60	0.27	0.001
	Tertiary	71	5.75	0.18	
	PGE	74	5.31	0.27	

*PGE: Post Graduate Education

a decent income. From their responses, many of the women had a basic knowledge of the concept of geophagia and the risks associated with the consumption of edible clays. A tiny but noteworthy portion of respondents (9%) claimed that the body can benefit from the micronutrients and antioxidants found in kaolin and bentonite clays. This agrees with the findings of Umudi (2017) and Ejike and Ogugua (2017) which showed that edible clays contain significant amounts of micro and macro elements. The results of this study also show that the women are not very aware of the nutritional and non-nutritional content of edible clays yet a greater portion of them were consuming the clays. This aspect differs from the findings of a few additional studies where knowledge improved dietary intake and overall health (Ahmad *et al.* 2022; Onyenweaku 2022), and it goes to show that people can sometimes make unhealthy

Table 4. Health status of respondents

Variable	Sub-variable	n	%
History of Anaemia	Yes	0	0
	No	195	100
Previously diagnosed with chronic diseases	Diabetes	116	67.40
	Hypertension	56	32.60
	Total	172	100
History of health issues during pregnancy	No	117	65.40
	Yes	60	33.50
	Not sure	2	1.10
Other health issues developed	Abdominal pain	12	20
	Catarrh & Cough	2	3.30
	Fever	14	23.30
	Malaria	24	40
	Typhoid	8	13.30
	Total	60	100
Had observed changes in subsequent pregnancy due to geophagia	No	167	93.30
	Yes	3	1.70
	Not sure	9	5

Table 5. Association between educational attainment and respondents' perceptions and practice of geophagia

Variable	Practice of geophagia	Pearsons Chi square	*p*-value (significance)
History of chronic diseases	Consumption of kaolin clay	19.720	0.000*
	Consumption of bentonite clay	27.197	0.000*
Experience of health challenges during pregnancy	Consumption of kaolin clay	8.292	0.081
	Consumption of bentonite clay	8.387	0.078
Having pregnancy-related illness due to geophagia	Consumption of kaolin clay	5.003	0.287
	Consumption of bentonite clay	6.199	0.185
History of chronic diseases	Frequency of consumption of the edible clays	45.76	0.000*
Experience of health challenges during pregnancy	Frequency of consumption of the edible clays	8.875	0.181
Having pregnancy-related illness due to geophagia	Frequency of consumption of the edible clays	7.253	0.298

dietary choices as a result of their unawareness. This can lead to grave consequences such as diet-related chronic diseases. Furthermore, the results from this study show an association between participants' educational level and their perceptions/practices as well as, income also influencing their perceptions/practices of geophagia. The higher the level of education of the participant, the higher the perception score and vice versa. Participants income levels also varied proportionally with their scores. Woywodt and Kiss (1999) on the contrary rejected the idea that poverty was the cause, pointing out that the practice of geophagia was common among the impoverished, slaves, and satisfied laborers and that it was not stopped by an abundance of food.

Some of the arguments put forth by geophagic people for its practice include detoxification of the body, nutrient supplementation, alleviation of gastrointestinal disorders such as diarrhea, nutrient supplementation, relief from morning sickness and cravings (Gomes & Silva 2007) or as part of cultural practices (Ngole & Ekosse 2012). Notwithstanding the apparent advantages of geophagia, certain research has linked the habit to detrimental health outcomes like iron deficiency anemia. (Mogongoa *et al.* 2011), dental problems (e.g enamel damage), perforation of the colon and erosion of the mucosal surface of the stomach (Barker 2005; Ekosse & Anyangwe 2012), hypokalaemia (Bisi-Johnson *et al.* 2010), zinc deficiency and apprehension (Singh *et al.* 2021) infection caused by parasites that spread Ascaris lumbricoides and other highly toxic bacteria that cause tetanus and botulism (Saathoff *et al.* 2002; Bisi-Johnson *et al.* 2010). Unfortunately, no proven treatments for pica have been established yet, although selective serotonin-reuptake inhibitors may offer some relief in some cases - but therapy and diagnosis need to be customized for each patient (Phakoago *et al.* 2019; Attarh *et al.* 2021).

It has been observed that the practice of ingestion of soils and clays may be intentional or unintentional. Previous research has traced the history and global prevalence of geophagia. Research indicates that the habit is not exclusive to any specific gender, age bracket, geographical location, ethnicity, or historical era (Njiru *et al.* 2011); however, young children are especially vulnerable to the soil-eating habit. Children aged below 20 months usually explore the environment by putting whatever they pick up into their mouths. Above this age however, deliberate consumption of soil/earth is often considered abnormal (Abrahams 2002). Some

pregnant women in the southern United States used to consume foods like clay, corn starch, and baking soda as part of a cultural practice. They believed that these foods prevented vomiting, promoted baby growth, treated swollen legs, and guaranteed the birth of healthy, attractive children. In addition, kaolin, or gray native clay, is a common food for expectant mothers in rural southern Georgia. They claim that the "dirt" helps them feel better and less sick during pregnancy and they crave for it (Odangowei & Okiemute 2015). This shows that eating clay is a common practice among women outside of Africa. In five more African nations namely: South Africa, Zimbabwe, Zambia, Swaziland and Malawi, where a similar study was conducted in their rural areas, the estimated prevalence level of geophagia was about 90% (Walker *et al.* 1997) which is higher than the 70% prevalence recorded in this study. The possibility also exists that geophagia could be declining with modernization. Several soil types have been reportedly consumed by individuals that are geophagic, such as termite mounds, red, white, yellow, and brown clay types, among other types of soil. This study focused on the consumption of just two edible clays – kaolin (white) and bentonite (grey). Louba *et al.* (2004), reports that in Kenya, earth from termite mounds and soft stone, referred to locally as "Odowa," were the two types of earth that Kenyan women preferred to consume. In this study carried out among women in southern Nigeria, the preferred type was bentonite clay because it was tastier.

Furthermore, a close look at the health implications of geophagia, not only shows negative effects but some benefits have been reported. Ekosse and Jumbam (2010) examined the mineralogy and chemistry of some commercially available geophagic samples from Cameroon and Nigeria, two West African countries where geophagia is highly prevalent. They concluded that clay-eaters may profit from their potential therapeutic and dietary benefits. For instance, calcium is known to be important for proper bone development, especially for foetuses and infants. Hooda *et al.* (2002) and Shkembi & Huppertz (2021) claim that calcium from edible clays augments the calcium obtained from other dairy sources such as milk and cheese. The assertion that certain pregnant women who are deficient in calcium are more susceptible to geophagia could be supported by this claim (Gomes & Silva 2007; Odangowei & Okiemute 2015). The findings of this study also show a direct association between the experience of illnesses during pregnancy, having a history of chronic diseases and the consumption of edible clays. Only the frequency of consumption of these clays did not seem to directly affect the participants' health status. According to Smith *et al.* (2000), some research also assert that geophagia introduces a direct soil-human geochemical pathway because an individual may receive vital micronutrients like iron (Fe) from the soils or clays they ingest. Trade in geophagic materials for medicinal purposes provides a source of revenue (Vermeer & Ferrel 1985) hence, there could be some economic and health benefits related to the practice of geophagia. Summarily, many factors seem to influence the perceptions and practices surrounding the practice of geophagia which is still quite common among women particularly pregnant mothers.

This study was limited to two cities in the Southern part of Nigeria due to lack of research assistants to go round other places for data collection. This limited the sample area and size. Another common issue with most surveys that can be challenging to verify, is the validity of the responses.

CONCLUSION

This study reports that despite modernization, the prevalence of geophagia among pregnant mothers is still relatively high. This may be as a result of the perceptions and practices on the consumption of edibles which have been reported by the women. The cross-sectional survey carried out at two different health centres in Cross River and Anambra states show that some of the perceptions and practices on geophagia are right – based on a review of existing literature. On the other hand, some perceived benefits from the consumption of edible clays are yet to be proven, hence they cannot be seen as correct. Kaolin clay was more consumed than bentonite clay but both clays were reported to be consumed in significant quantities by the participants of the study. Despite not being well acquainted with the nutritional and non-nutritional content of the clays, most women still indulge in the practice of geophagia. Previous research has reported that geophagia is

implicated in maternal anaemia, hypokalemia, zinc deficiency, apprehension and other health challenges. The women in this study however did not report having any serious health issues during pregnancy as a result of their clay consumption. Nevertheless, increased awareness of the possible health consequences of geophagia will go a long way in persuading women, especially pregnant mothers, to consume the clays with caution. Women are encouraged to consume healthy snacks such as fruits, as a way of reducing the cravings of geophagia during pregnancy.

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DECLARATION OF INTERESTS

The author declares no conflict of interests.

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Nutrient Profiling Model Towards Recommendation of A Healthy Diet: A Scoping Review

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ABSTRACT

The objective of this study is to identify the availability of Nutrient Profiling (NP) models worldwide and discuss their application. This scoping review is based on the Preferred Reporting Items for Systematic Review and Meta-Analyses Extension for the Scoping Review (PRISMA-ScR) and the Arksey and O'Malley framework. Articles related to NP among adults published from 2012 to 2022, written in English, were retrieved from the Web of Science, Science Direct, Scopus, and Pubmed databases. Mendeley software was used for database acquisition and MS Excel for the syntesis process. Only 17 articles out of 2,019 article titles identified met the inclusion criteria for the review. This review discovers that the applications of NP in nutrition policies include food labelling, Front-Of-Pack (FOP), and regulations on food marketing, health, and nutrition. Fibre is the nutrient that needs to be included in the NP application compared to saturated fats, fatty acids, sodium, and total sugar. This scoping review demonstrates the scientific basis of the NP model's development in public health policy, leading to advocacy and the recommendation of healthy diets.

Keywords: adults, healthy diet, nutrient profiling, nutrient density, nutrient-rich food index

INTRODUCTION

Excessive intake of unhealthy diets is also one of the main causes of Non-Communicable Diseases (NCDs), such as stroke, coronary heart disease, and some types of cancer other than smoking, alcohol consumption, and physical inactivity (WHO Regional Office for Europe 2016). In 2015, the World Health Organization (WHO) stated that factors such as financial levels, personal preferences and beliefs, cultural traditions, and geographical location, such as climate change, pose challenges to the accessibility and availability of healthy and nutritious foods.

The definition of Nutrient Profiling (NP) is "the science of categorising or ranking foods with their nutritional composition". Therefore, NP is a helpful instrument to motivate consumers to choose healthier foods (WHO 2015). Hence, it could prevent the risk of diseases and promote a healthy diet (WHO 2011). Globally, NP is used as a tool for developing applications related to nutritional policy. According to Labonté *et al.* (2018), the applications of NP models include establishing health or nutrition claims regulations, implementing restrictions on food marketing to children, and assisting consumers in making decisions about which food products to sell in schools through food labelling systems. For instance, in the United Kingdom, the Food Standards Agency (FSA) developed the Nutrient Profiling Model to track food product advertisements targeted towards children (Scarborough *et al.* 2007; Department of Health, Food Standards Agency, British Retail Consortium 2013), while the United States developed the Nutrient Rich Food (NRF) model for their consumers (Fulgoni III *et al.* 2009). The British FSA uses colours to label the product's nutrition level, called the Nutri Score, with green indicating the highest nutritional quality and red

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indicating products with lower nutritional quality. The same food labelling is also used in France with the Nordic Keyhole scheme and Health Star Rating in Australia and New Zealand.

NP ranks foods based on their nutrient content and uses them for regulating health claims, nutrition labels, and marketing and advertising towards children (WHO 2011). Some NP models developed by scientists, government agencies, and the food industry focus on limiting sugar, fat, and sodium, and some emphasise nutrients that benefit health, such as protein, vitamins, dietary fibre, and iron. NP models are often tailored through the use of science-driven rule development procedures, such as the selection of reference amounts and index nutrients, the creation of a suitable nutrient density calculation algorithm, and the validation of the selected nutritional profile model against a healthy diet. Although there are several available NP models, little is known about their applications in relation to the recommendation of a healthy diet. Thus, this scoping review aims to identify the established models of NP that have developed as a tool to establish public health interventions toward a healthy diet.

METHODS

Sources of information and search strategy

NP articles, full text, were included in this scoping review. Arksey & O'Malley's (2005) framework and the Preferred Reporting Items for Systematic Review and Meta-Analyses Extension for the Scoping Review (PRISMA-ScR) method (Trico *et al.* 2018). PubMed, Scopus, Science Direct, and Web of Science are the four databases used in searching research papers published in English between 2012 and 2022. To find the established NP models as a tool to form public health interventions related to nutritional status, suitable keywords were chosen to search the relevant articles. The keywords used in the database machines comprised nutrient density, nutrient-rich, nutrient profiling, nutrient profiles, affordable diet, low cost, healthy eating, healthy food, and adults. The search strategy included all possible combinations of key search terms, which were "nutrient density" OR "nutrient-rich" OR "nutrient rich food index" OR "nutrient dense" OR "macronutrients" OR "diet quality" OR "dietary index" OR "diet index" OR "nutrient profiling" OR "nutrient profiles" OR "food profiles" OR "nutrient profile" OR "nutritional profiles" AND "affordable diet OR "low cost" OR "modest" AND "healthy eating" OR "health food" OR "healthy diet" OR "adequate diet" OR "adequate food" OR "good nutrition" OR "proper nutrition" AND "adults."

One of the research questions that emerged from reviewing the literature and recognising the need for the study was, "What is the available model related to NP and methods for developing it?" The other research question that arose during this stage was, "What are the assumptions used during the development of NP?" Additionally, the relation of NP models to a healthy diet was explored.

Study selection and data charting

The selection of the research papers was based on the study objectives. Citations that did not address the research questions or that were deemed irrelevant were excluded according to the inclusion and exclusion criteria. The inclusion criteria are the methods used in the development of NP models and the focused approaches to the various NP models. The exclusion criteria are the articles that were not related to NP and published outside of the range of 2012 to 2022. The articles were screened based on their titles and abstracts. Those that did not meet the outlined scope were excluded, and for those that did, full articles were extracted from the databases and revised to ensure they answered the research questions before being selected for final review. Mendeley software was used to manage all research papers, and the data extracted were documented in Microsoft Excel. Two researchers charted the data independently, which includes author(s), years of publication, country or organisation, objectives, methodology, results, and conclusions.

Collating, summarising, and reporting the results

Table 1 lists the characteristics and findings of the NP models from the selected articles. Each article was thoroughly screened for eligibility by scrutinising its title and abstract. The full text was then retrieved for further assessment of the suitability of the studies based on the research questions. The extracted data were then analysed to generate a summary of NP characteristics based on the research scope. Limitations and research gaps were also identified for future research. The

process of selection is outlined in Figure 1. A total of 2,019 titles were identified from the electronic databases. Four hundred articles were removed due to duplications and other reasons, such as the fact that the studies were conducted among children, adolescents, and the elderly and were not focused on NP. Mendeley software was used to record, track, sort, and verify the duplicate articles. Out of 1,619 abstracts that were assessed for eligibility, only 17 articles met the inclusion criteria (Table 1). The term "study" in this review refers to the selected articles.

RESULTS AND DISCUSSION

Most studies on NP models were conducted in European countries (n=7), followed by Asia (n=3) and the United States (n=2). There are also studies conducted in other countries, for instance, Australia and New Zealand (n=1); Australia, France, the United Kingdom, and the United States (n=1); and the United States and France (n=1). Sample sizes are range from 147 to 41,255. Only four studies focused on food and beverage products, and the others included one type of sample meal in the research, such as breakfast cereal, Romanian traditional dishes, and packaged products (Voinea *et al.* 2020; Mhurchu *et al.* 2016; Debeljak *et al.* 2015; Vlassopoulos *et al.* 2017; Duran *et al.* 2021). Table 1 describes the summary of the NP model related to a healthy diet.

Type of NP models

This study found that there are various NP models developed, namely the Nutrient Profiling System (NPS), NOVA food classification, Pan American Health Organization (PAHO), Chilean nutritional FOP labelling policy, British Office of Communications (Ofcom), Nutrient Profiling Scoring Criterion (NPSC), UK Ofcom, Food Standards Australia New Zealand (FSANZ), Traffic Light, Nutri Score, and others. In general, the NP models are categorised into two classes: food category-specific (n=5) and across-the-board (n=12).

NP models may endorse restrictive policies pertaining to regulations on child-directed marketing and labelling in the United States to aid the nation's battle against obesity and NCDs (Frank *et al.* 2021). Thorough evaluations of the NP models are crucial for their effective use in food and public health policies, especially in regulating nutritional labelling to assist consumers in choosing healthier foods (Duran *et al.* 2021). In addition, the limited availability of healthy options in staple foods is alarming, empathising the potential of product reformulation to enhance food quality that will have a positive impact on the population diet (Mhurchu *et al.* 2016).The European Union's legislation on NP remains a persistent concern, progressing at a slow pace since 2009.

A fundamental benefit of continuous and universal NP models is the capability to compare nutrients within and outside of certain food categories such as "high in fat", "high in sugar", or "high in salt." Nevertheless, the NP model's design should be taken into consideration while interpreting the results. Since the model only takes into account a limited number of nutrients, it cannot provide a comprehensive analysis of which meals are healthier. Therefore, a more comprehensive approach would be required, especially regarding the selection of food nutrients and ingredients. The methodical approach to NP can generate a wide range of NP models, even for the same goal. Furthermore, it is necessary to

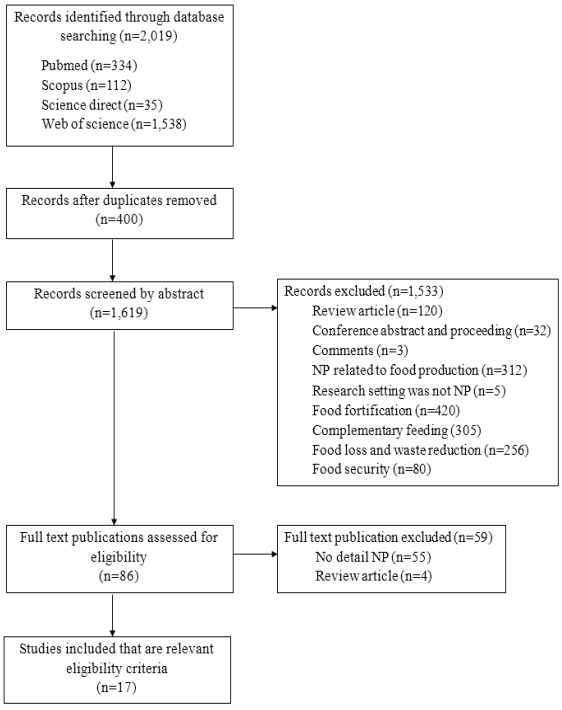

Figure 1. The PRISMA flow article selection diagram

Table 1. Summary studies on Nutrient Profiling Model related to a healthy diet

Journal title (author, year, country)	Study design & type of sample	NP model name & type of model	Methods in developing NP	Application of NP	NP model related to a healthy diet
Journal of Nutritional Science (Sluik *et al.* 2015) Netherlands	Cross-sectional & Respondents (n=2,106)	NRF. Acrross-the-board	Fifteen NRF index scores are compared to energy density and the DHD-Index.	No significant variations in the DHD index prediction based on the 15 NRF index scores.	NRF9.3. Dairy products, cereals, and veggies contributed the most to the research population's index scores.
The Journal of Nutrition Nutritional Epidemiology (Julia *et al.* 2015) French	Intervention & Respondents (n=3,741)	NPS. Acrross-the-board	Dietary data from 24-hour records between the FSA NPS DI.	A higher risk of developing MetS was substantially linked to poorer diets identified by the FSA NPS DI.	Using NPSs in public health campaigns could encourage people to choose healthier foods could lower their chance of having MetS.
Nutrients (Frank *et al.* 2021) South Africa	Cross-sectional & Packaged foods (n=6,747)	NOVA.	Foods that were packed with nutritional information had their nutritional composition checked as part of the evaluation process.	It is best to modify an NPM and support regulations with a stringent NPM that restricts the amount of unhealthy food ingredients.	Restrictive laws child-directed marketing and labeling in South Africa may be supported by this NPM.
Public Health Nutrition (Duran *et al.* 2021) Brazil	Cross-sectional & foods and beverages (n=11,434)	PAHO and Chilean nutritional FOP labelling policy. Across-the-board	PAHO model and the NPMs used in the Chilean nutritional FOP labeling policy.	Under the PAHO two thirds of packaged products receive FOP warning labels	Level of agreement and strictness amongst the evaluated NPM. Additional high-sugar meals and beverages were found by the PAHONPM to be among the main sources of sugar and energy intake.
Public Health Nutrition (Mhurchu *et al.* 2016) Australia & New Zealand	Cross sectional & food and beverage product (n=23,596)	Ofcom and NPSC. Across-the-board	The relationships between NPSC scores and the amounts of sug-ar, sodium, saturated fat, and calorie density were measured.	Packaged food products are scored by NPSC. Foods in Australia scored lower than those in New Zealand.	Nutritional standards were met by 50% of packaged goods sold in Australia and New Zealand to support health claims.
Acta Alimentaria (Debeljak *et al.* 2015) Slovenia	Cross-sectional & breakfast cereal (n=221)	UK Ofcom, FSANZ and Traffic Light. Food category-specific	Three nutrient profiling technologies were used to analyze the nutritional composition of breakfast cereals.	The UK Ofcom and FSANZ methods provide outcomes that are more in line with the usage of claims, but the modified Traffic Light system exhibits the most noticeable improvement.	EU's nutrient profile legislation has been a persistently slow-moving matter, yet nonetheless a cause for concern. Likewise, the use of statements about nutrition, health, and related topics on food labels.
European Journal of Nutrition (Kissock *et al.* 2022) Australia, France, UK & US	Cross-sectional & multiple age group. Australia (n=12,153) France (n=2,624), UK (n=4,946), & US (n=5,266)	Nutri Score. Food category-specific	Data on food composition and dietary intake from Australia, France, the United Kingdom, United States, and we compared the original and updated Nutri Scores.	Correlations between whole-grain content and food nutritional score were increased.	Incorporate a whole-grain component into the Nutri Score algorithm in order to better represent.

Continue from Table 1

Journal title (author, year, country)	Study design & type of sample	NP model name & type of model	Methods in developing NP	Application of NP	NP model related to a healthy diet
Foods (Ridoutt 2021) Australia	Cross-sectional & multiple age group (n=9,000)	NRFai. Across-the-board	Excessive and inadequate nutrient consumption among Australian adults was taken into account when developing an alternative Nutrient Rich Food Index.	The new models are applied to a variety of dairy products and substitutes, diets high in protein, and foods that are optional.	The advantage of this type of weighing is that it highlights the nutrients that are less prevalent in the overall food chain.
Information (Voinea *et al.* 2020) Romanian	Cross-sectional & Romania traditional dishes (3 menus)	Nutri Score. Food category-specific	Evaluate the traditional Romanian diet's nutritional based on the Nutri Score algorithm.	The findings showed that the traditional menus do not align with a sustainable and balanced eating pattern.	Establishment of a new paradigm for modern Romanian cuisine. Romanian consumers' awareness of changes is referred to as acceptance.
Nutrients (Pandav *et al.* 2021) India	Cross-sectional & food and beverages (n=41,255)	Nutrient profiling; front-of-package labels. Across-the-board	The WHO SEARO and the CWO Phase 3 are two nutritional profile models that were applied to food products that were sold in India.	According to the results, there would be at least one "high-in" level warning label.	This research shows that when evaluating the usefulness of warning labels, a wider range of food products should be included.
Nutrients (Drewnowski & Fulgoni III 2020) United States	Cross-sectional & multiple age group (n=23,643)	NRFh-3.4.3. Across-the-board	Based on three subscores, the new NRFh was created. NRx is the definition of the subscore, which is based on x nutrients to encourage. The MyPlate food groups provide the basis for the subscore.	Six nutrients and four dietary groups (fiber, potassium, and PUFA+MUFA; whole grains, dairy, fruit, nuts, and seeds; saturated fat, added sugar, and sodium) make up the new NRFh3:4:3 score	The NRFh3:4:3 and NRFh4:3:3 models showed strong correlations with HEI-2015 scores, a diet quality metrice.
British Journal of Nutrition (Masset *et al.* 2015) United Kingdom	Longitudinal study & adults (n=7,251)	SAIN, LIM. Across-the-board	127-item FFQ. The number of foods consumed more than once a week was defined as the FVS. Using the UK Ofcom and French SAIN, LIM nutritional profile models.	The risk of all-cause mortality was shown to be reduced, when comparing the third quartile of the FV(Ofcom) to the first quartile.	The findings support the idea that a wide variety of foods should be promoted.
Nutrients (Mainardi *et al.* 2019) United States	Cross-sectional & multiple age group (n=1,348)	Nestle Nutrition Algorithm. Across-the-board	Based on age- and gender-specific healthy guidelines for energy and nutrient intakes over a 24-hour period, the new Nestlé NNA was developed.	There were strong relationships between the HEI 2010 scores and the NNA method. NNA mean scores for two excellent meal plans (MyPlate and DASH) during a seven-day period.	The NNA was able to effectively portray both the inferior quality of diets that are really followed in the US and the superior MyPlate and DASH menu plans.

Continue from Table 1

Journal title (author, year, country)	Study design & type of sample	NP model name & type of model	Methods in developing NP	Application of NP	NP model related to a healthy diet
European Journal Nutrition (Vlassopoulos *et al.* 2017) US and France	Cross-sectional & food and beverages (8 food groups)	NNPS.	NNPS is a category-specific system that determines the amount of nutrients to be ingested and additional nutrients to encourage cannot make up for excessive levels of nutrients to limit.	NNPS was linked to an overall downward trend for all nutrients to limit. There was a reduction in the total sugar and sodium. Less consistency in the lowering of total fat and saturated fatty acids among the groups.	Significant reductions in sodium, total sugar, and total fat were linked to the application of the NNPS.
The Journal of Nutrition Nutritional Epidemilogy (Julia *et al.* 2014) France	Randomised & multiple ages (n=4,225)	FSA British food agency. Across-the-board	Repeated 24-hour food logs were used to gather data. The FSA nutritional profile of each food was used to describe it.	Individuals who scored higher on the fruit and fish consumption also consumed fewer snack foods. Less saturated fat and more vitamins and minerals.	In the French setting, the FSA nutritional profile system shows good validity in characterising individual diets.
PLOS One (Egnell *et al*. 2020) Switzerland	Cross-sectional & adults (n=1,088)	Nutri Score. Across-the-board	To the goods within the sets according to their nutritional quality, consumers were asked to choose of three foods with varying nutritional profiles.	Every FoPL was viewed positively, with very slight variations amongst them. The greatest percentage of improvement in dietary choices was shown by the Nutri Score.	Nutri Score was the most effective FoPL.
Nutrients (Finkelstein *et al.* 2019) Singapore	Intervention & adults (n=154)	Multiple traffic light system. Nutri Score	Online grocery store using a (in-person) design.	Based on this metric, neither label is statistically superior, but both considerably improve modified AHEI.	To increase the overall quality of the diet, NS might be the better choice. If the goal is to decrease total energy-consumption, MTL might work better.

AHEI: Alternative Healthy Eating Index; CWO: Chilean Warning Octagon; DASH:Dietary Approaches to Stop Hypertension; DHD-INDEX: Dutch Healthy Diet Index; FFQ: Food Frequency Questionnaire; FOP: Front-Of-Pack; FoPL: Front-of-Pack Labeling; FSA: Food Standards Agency; FSANZ: Food Standards Agency New Zealand; FVS: Food Variety Score; LIM: Limited Nutrient Score; MetS: Metabolic Syndrome; MTL: Multiple Traffic Lights; MUFA: Monounsaturated Fatty Acid; NNA: Nestle Nutrition Algorithm; NNPS: National Nutrition Policy and Strategy; NP: Nutrient Profiling; NPM: Nutrient Profile Model; NPS: Nutrient Profiling System; NPS DI: Nutrient Profiling System Dietary Index; NPSC: Nutrient Profiling Scoring Criterion; NRF: Nutrient Rich Food; NRFai: Nutrient Rich Food Index; NRFh: Nutrient Rich Food Hybrid Score; NS: Nutrition Science; PAHO: Pan American Health Organization; PAHONPM: PAHO Nutrient Profile Model; PUFA: Polyunsaturated Fatty Acid; SAIN: Score of Nutritional Adequacy of Individual Foods; SEARO: South-East Asia Region Organization

test various models to verify if they provide the desired outcome (Scarborough *et al.* 2007).

Theoretically, the classification of food products leaves no opportunity for subjectivity as there are only two food categories, namely, foods and drinks. However, the natural variation in the nutritional composition of foods between food categories is less likely to be explain. However, there are still important issues that require further investigation, such as establishing food groups, selecting an acceptable NP for each food category or food group, and selecting food categories based on cultural differences while balancing them (Labonté *et al.* 2018; Rayner *et al.* 2013).

Nutri Score includes a whole-grain component in its algorithm, which aligns with

dietary guidelines and better represents the role of whole grains in improving dietary quality (Kissock *et al.* 2022). Subjective decisions on nutrient selection are avoided by using an NP model that considers the frequencies of both excessive and insufficient nutrient intake in the target population. Such decisions run the risk of undermining confidence in NP tools within the broader food system (Ridoutt 2021).

This new paradigm of acceptance, adaptation, and transformation for contemporary Romanian cuisine emphasises the need to include a wider variety of food products when assessing the value of warning labels (Voinea *et al.* 2020). Nutrient- and food-group-based NP models have the potential to become integral components of dietary guidance (Drewnowski & Fulgoni III 2020).

Methods in developing NP models

This study found that there are six methods used for NP development, including: 1) Comparing the NRF index scores to the current index (Sluik *et al.* 2015); 2) Developing an NP model using data from a one-day dietary record and a 24-hour dietary recall (Julia *et al.* 2015); 3) Analysing the impact of price or NP changes on food categorisation, purchased food labels, and overall food quality (for example, healthier or less healthy food groups) and weighting the techniques according to their food consumption to represent the country's population (Debeljak *et al.* 2015); 4) Assessing the nutritional value of packaged foods with nutritional labels in the food supply chain of South Africa (SA) (Frank *et al.* 2021); 5) Comparing the PAHO model and the NP model used in the Chilean nutritional FOP labelling policy with a NPM proposed by the Brazilian National Health (Duran *et al.* 2021); 6) Calculating the NPSC scores and estimating the products' proportion to eligibility displays the health claims (Mhurchu *et al.* 2016).

Our review found that the majority of NP models developed concentrate on specific nutrients, which are fat, saturated fats, sugars, and salt. However, some of the models were insufficient in capturing the exact nutritional density needed to identify healthy foods (Drewnowski *et al.* 2019). There is a need to create a hybrid NP method that comprises nutrients as well as all suitable food groups and dietary additives (Drewnowski *et al.* 2019; Maillot *et al.* 2018). The hybrid NP model may provide better alignment between policy applications and quantitative assessments of nutrient density to promote healthier food choices. This combination will improve our current strategy of providing dietary advice, create a stronger nutritional policy, and eventually create better benefits for public health (Drewnowski *et al.* 2019). The hybrid nutrient density score takes into account both desirable food groups and nutrients. For example, NP models can be used to design nutrition labels in food packaging, making it easier for consumers to identify healthier food options. Hybrid models can inform the development of labelling schemes like Nutri Score, which assigns color-coded labels based on their nutritional quality.

The methods used in NP model development were mainly to address the quality of micro- and macronutrients in the assigned goods and to determine whether to classify the model in a general food category or a specific one. In the event that local recommendations were lacking, WHO/FAO standards were used as a reference to determine the basis for nutrient consumption using the 100 g, per 100 kcal, or per serving size calculation.

During the development of NP models, a crucial decision emerged: Whether these models should be compensated. This led to several questions that demanded careful consideration. Firstly, should NP scores be designed to strike a delicate equilibrium between beneficial nutrients and nutrients to limit? This deliberation sought to optimise the food product's overall nutritional value. Secondly, the process of formulating the NP algorithm necessitated an important choice: Should the scoring system be continuous, employing letters or numbers, or would a simpler binary approach with just yes or no suffice?

Each of the numerous reference quantities used to create NP models has various benefits and drawbacks. For instance, the use of per 100 g or per 100 mL is easy to standardise and consistent with food labelling, but a model built using this reference value could penalise a meal that has a high nutrient content per 100 g and is consumed infrequently or sparingly (Drewnowski & Fulgoni III 2008).

The issue of consuming too many energy-dense meals could be effectively addressed by an NP model that is based on energy units, the Nutrient-Rich Food Index, or the Nordic Keyhole

system and would facilitate the comparison of foods with different energy densities, like liquids and solids. However, for meals with a very low energy content, this reference scale might not be realistic, and consumers would find it difficult to comprehend (European Food Safety Authority (EFSA) 2008).

While creating an NP model, the nutrients and food elements need to be tested in accordance with designated markers, as well as those that are not included. For example, the FSA/Ofcom model algorithm did not incorporate total fat as it was consistent with energy (Rayner *et al.* 2013). Enhancing existing NP models is crucial, which can be achieved by replacing total sugars with other alternatives (Labonté *et al.* 2018).

The validation of NP models is another challenging process in this industry. The validation and testing of the NP models are necessary to determine the appropriate categorisation of foods and their suitability for use in nutrition claims.

Application of NP models

The application of NP models is to create thresholds to meet specific dietary guidelines, algorithms to assess the overall foods' NP, or criteria based on nutrient reference values (Santos *et al.* 2021). Santos *et al.* (2021) also found that the applications of NP models create healthier food labelling, enforce restrictions on marketing products to children, and support regulation of claims. In addition, the NP model also sets stricter criteria in food classifications than carries permission in nutrition and/or health claims (Debeljak *et al.* 2015).

In conjunction with educational campaigns promoting a healthy diet, FOP nutrition labelling is one of the common policies enforced to prevent chronic diseases related to eating habits. However, the nutrition information on food labels may sometimes be confusing for certain consumers. Nor *et al.* (2023) reported that adolescents use food labels to choose better-quality and healthier foods. Therefore, it is important to strengthen the influence of this knowledge on dietary health and nutrition literacy to support educational efforts and raise consumer awareness (Moore *et al.* 2018). The involvement of food businesses is a must to further encourage the production of healthier products by reformulating food items and nutrition labelling concerning the target population (Hawkes *et al.* 2015). Therefore, policymakers ought to acknowledge NP models as a useful instrument for directing food reformulation and monitor their impact on improving people's diet choices (Labonté *et al.* 2018).

NP model related to a healthy diet

In reviewing a healthy diet, vegetables, cereals, and dairy products contribute significantly to the population's index score. The utilisation of nutrient density models offered further insights into dietary quality compared to energy density (Sluik *et al.* 2015). By implementing Nutrient Profiling Systems (NPS) in public health, it could encourage consumers to make healthier food selections, which will potentially decrease the likelihood of developing Metabolic Syndrome (MetS) (Julia *et al.* 2015). MetS is a health disorder that often occurs together with hypertension, hyperglycemia, excess abdominal fat, and abnormal cholesterol levels and leads to serious health problems such as diabetes, heart disease, and stroke. Therefore, making healthier food choices with the help of NPSs could potentially reduce the risk of developing MetS.

The methodology of the proposed system need to be validated on the impact of nutritional intake by the consumers in helping them achieving healthier diets (Vlassopoulos *et al.* 2017). The NP system developed by the FSA proves strong validity in characterising individual diets in France. Therefore, public health nutrition programmes like FOP nutritional information could serve as a foundation (Julia *et al.* 2014).

A NP model should be developed and applied sustainably using a holistic approach. In the framework for NP model development, it should be taken into account whether there is any reliable data demonstrating the link between nutrition and health. A hybrid NP technique that takes into account all nutrients and desirable food groups and components has the potential to capture more healthy foods compared to the current NP models. Therefore, in-depth research is suggested to discover the suitability of these models and how they will align with the national context (Drewnoski *et al.* 2019).

In 2020, Drewnowski & Fulgoni III indicated that NP models based on food groups and nutrients should be included in dietary guidelines as they help promote varieties of healthy foods (Masset *et al.* 2015). For instance, the NNA

was able to capture that the diets consumed in the United States are of poorer quality than the MyPlate and Dietary Approaches to Stop Hypertension (DASH) menu plans (Mainardi *et al.* 2019).

Overall, the types of models and methods used in developing NP models depend on the data from the nutrient composition database, for instance, the brand of food available, the availability of nutrients, and so on. There were no standard nutrients to be selected in the NP models. However, the common ones are energy, sodium, total or added sugar, and saturated fat. Vitamin A, B-6, B-12, D, iron, calcium, and zinc are nutrients commonly included in the NP models.

The studies included in this review use various research methodologies in developing NPs and their application towards advocating a healthy diet. There are also several limitations found in this present study. The studies included multiple development methods with different interpretations. This may lead to confusion for both consumers and policymakers. Thus, the NP models urgently need to be optimised and standarised (WHO 2011). Many food groups would need to be created in order to include all foods and food items due to the absence of regional (European) agreement on the definition of food categories. As a result, the NP model's main flaw is its inability to accurately adjust, handle, and classify a large range of food groups (Drewnowski & Fulgoni III 2008).

A wider NP system would aim to provide a more comprehensive view of a food's nutritional value. This could be useful as different nutrients play various roles in health, and a diet that's diverse in beneficial nutrients is generally associated with better overall well-being. It's important to note that there isn't a single "widest" universally accepted as the best. Different systems might be tailored to specific dietary goals or health concerns. Some well-known include the Health Star Rating, the Nutri Score, the Nutrient Rich Food Index, and the NOVA classification system. Each of these considers various nutrients and factors to provide a simplified label or score that consumers can use to compare and choose healthier food options. The NP system depends on its accuracy in reflecting a food's nutritional quality and its ability to guide consumers toward healthier choices. Different countries and organisations might adopt different systems based on their dietary guidelines and population health priorities.

CONCLUSION

Most NP models were initiated with the intention of preventing obesity in high-income nations by penalising items that are rich in calories. Several of these NP models were unable to monitor the nutrient content of foods that have been fortified and, therefore, were unable to support the efforts to increase the nutrient content of the food supply in low- and middle-income countries. The persistent vitamin and mineral deficits need to be addressed in new NP models designed only for low- and middle-income countries. Assuming data on nutritional composition is available in low- and middle-income countries, these models can be developed according to pre-existing principles and guidelines.

NP models have the potential to support restrictive laws like those governing FOP labelling and child-directed marketing; hence, they might be included in dietary recommendations based on nutrients and food groupings. These regulations will support the effort to combat obesity and NCDs. The development of NP and the assessment of nutrient density models are based on a number of methods. These choices of methods may vary depending on the model's goal, but they must always be developed with transparent and unbiased methods that meet scientific standards. In conclusion, the use of NP models in public health campaigns may encourage people to choose better foods, lowering their chance of developing non-communicable diseases

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The authors state no conflict of interest in the implementation of this research from start to finish.

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