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Food literacy and healthy diets in childhood and adolescence

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Food literacy and healthy diets in childhood and adolescence

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Editorial: Food literacy and healthy diets in childhood and adolescence

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Editorial on the Research Topic
Food literacy and healthy diets in childhood and adolescence

The global shift in food systems has made processed food, which is nutrient-poor and energy-dense, readily available and convenient for individuals across all age groups, with a particular focus on children. This phenomenon significantly influences food choices, leading to the disruption of dietary patterns. Two crucial concepts related to health literacy play a pivotal role in supporting the promotion of healthy dietary habits: nutrition literacy (NL) and food literacy (FL). The definition of NL is "*the degree to which individuals have the capacity to obtain, process, and understand nutrition information and skills needed in order to make appropriate nutrition decisions*" (1); where FL has been defined as "*the scaffolding that empowers individuals, households, communities or nations to protect diet quality through change and strengthen dietary resilience over time. It is composed of a collection of inter-related knowledge, skills and behaviors required to plan, manage, select, prepare and eat food to meet needs and determine intake*" (2).

The support for developing NL and FL among children begins in their preschool years, shaping their food choices and building food-related skills and practices that will support their habits later in life. The objective of this research is to compile papers that enhance our understanding of the impact of implementing and developing NL and FL among infants, children, and school-age students on their health-related patterns. The Research Topic consists of 11 articles.

A review paper by Hoteit, Mansour et al. reveals the prevalence of NL and FL in 10 Arab countries. Approximately 28% of Arab adolescents exhibited poor NL, with 60% of their parents being food illiterate. Variations were observed in different countries, such as Qatar (44%), Lebanon (37.4%), and Saudi Arabia (34.9%). Several factors, including adolescents' age, gender, education level, primary caregivers, employment status, and the inclusion of nutrition education in schools, predicted the nutrition literacy levels of Arab adolescents. Additionally, parental weight status, health status, parental food literacy level, and the number of children per household were significant determinants. Hoteit, Mohsen et al.'s data indicate that FL and NL can mitigate malnutrition in Lebanon. In Saudi Arabia, Bookari's (a) study demonstrated that approximately 46% of parents of adolescents had poor food literacy, influencing their health status. Parental education level and socioeconomic status were also associated with food illiteracy.

Another study by Bookari (b) in Saudi Arabia revealed that nearly half of the adolescents (44.6%) had poor nutrition literacy. Factors such as gender, residential area, weight status, school status, and caregivers other than parents influenced FL and NL. Culinary lessons focusing on vegetables in schools were shown by Policastro et al. to drive dietary behavior change and self-efficacy to cook, impacting the acceptance of vegetables. Cao et al.'s study in primary and secondary schools indicated that children (8–15 years old) with gender identity concerns exhibited higher frequencies of unhealthy behaviors, particularly in consuming carbonated beverages. Ding et al. emphasized the importance of providing dairy products to infants and young children, which led to improved intake of essential nutrients.

In Egypt, Bonsu and Addo reported that one in every six children under 5 years was overweight or obese. Determinants included high birth weights, consumption of large portions of protein foods, and mothers in the rich wealth quintile. Lack of education on FL and breastfeeding negatively affected the health status of these children, as shown in Alotiby's systematic review linking breastfeeding to protection against chronic diseases like obesity and diabetes mellitus.

Tang et al. highlighted the association between the lack of FL among mothers in China and the prevalence of feeding difficulties in young children. The gap in FL and NL affected feeding styles, contributing to issues such as forcing children to eat and allowing play during mealtime. Finally, Chuang et al. investigated the dietary profile of pediatric obstructive sleep apnea (OSA) patients, emphasizing the importance of integrating a FL system for parents to reduce unhealthy patterns among children, a significant factor in OSA.

In conclusion, this book provides readers with updated data and studies from multiple countries, presenting a wealth of new information on FL and NL. The papers published in this e-book underscore that there are still many aspects within the realm of FL and NL that require further clarification and understanding.

Author contributions

MH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. RQ: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. RT: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Dairy fortification as a good option for dietary nutrition status improvement of 676 preschool children in China: A simulation study based on a cross-sectional diet survey (2018–2019)

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Background: Chinese children are deficient in several essential nutrients due to poor dietary choices. Dairy products are a source of many under-consumed nutrients, but preschool children in China consume dairy products significantly less than the recommended level.

Methods: From the cross-sectional dietary intake survey of infants and young children aged 0–6 years in China (2018–2019), preschool children (age: 3–6 years) (n = 676) were selected. The four-day dietary data (including 2 working days and 2 weekends) collected through an online diary with reference to the food atlas were used for analysis and simulation. In scenario 1, individual intake of liquid milk equivalents was substituted at a corresponding volume by soymilk, cow's milk, or formulated milk powder for preschool children (FMP-PSC). In scenario 2, the amount of cow's milk or FMP-PSC increased to ensure each child's dairy intake reached the recommended amount (350 g/day). In both scenarios, the simulated nutrient intakes and nutritional inadequacy or surplus were compared to the survey's actual baseline data.

Results: It was suggested suggested that replacing dairy foods with FMP-PSC at matching volume is better than replacing them with soymilk or cow's milk to increase the intake of DHA, calcium, iron, zinc, iodine, vitamin A, vitamin B_1, vitamin B_3, vitamin B_{12}, vitamin C and vitamin D. Moreover, our results suggested that adding FMP-PSC to bring each child's dairy intake

to the recommended amount can bring the intakes of dietary fiber, DHA, calcium, iron, zinc, iodine, vitamin A, vitamin B_1, vitamin B_3, vitamin B_9, vitamin B_{12}, vitamin C and vitamin D more in line with the recommendations when compared with cow's milk.

Conclusion: Accurate nutrition information should be provided to the parents of preschool children so as to guide their scientific consumption of dairy products and the usage and addition of fortified dairy products can be encouraged as needed.

KEYWORDS

Chinese preschool children, formulated milk powder, cow's milk, soymilk, simulation

Introduction

Preschool children (age: 3–6 years) are still undergoing rapid physical, psychological, and behavioral development, which increases their need for several nutrients, such as protein, polyunsaturated fatty acid, calcium, iron, zinc, vitamin A, B vitamins, vitamin C, and vitamin D (1, 2). Additionally, during this period, children's self-awareness, curiosity, and imitation ability are also enhanced, and they are prone to developing various unhealthy eating and lifestyle habits, putting them at risk of nutritional imbalance (3, 4). Therefore, preschool children's balanced nutrition should be provided by a balanced diet composed of a variety of foods, which should be further strengthened and consolidated to lay a foundation for healthy and good dietary behavior throughout their lives.

Although the status of child undernutrition in China has substantially improved due to economic growth, the problem of inadequacy or lack of dietary micronutrients has become prominent. According to China's national dietary survey, children's dietary mineral and vitamin intake remained inadequate in the past decade (5). Dairy products, as a good or excellent source of protein, calcium, phosphorus, magnesium, zinc, iodine, potassium, vitamin A, B vitamins, and vitamin D, play an important role in daily dietary recommendations in the dietary guidelines worldwide and are recognized as an ideal dietary composition to meet the growth and development needs of children and improve their nutritional status (6, 7). However, influenced by the conventional diet culture, dairy consumption is not a long-standing dietary practice in most Chinese households (8). In addition, regional economy, family income, nutrition knowledge, and other aspects also affect dairy consumption in China (9). Although the popular science propaganda to promote children's dairy consumption persists, the dairy intake of children in China is far from the recommended level. According to survey data, 44.6% of children aged 2–5 years in China consumed dairy products, with the median amount being 106.7 ml/day (5). According to the scientific research report on dietary guidelines for Chinese residents (2021), a lack or low intake of dairy products in their diet is the direct cause of inadequate calcium, vitamin A and other nutrient intakes (6).

Nutritional fortification is one of the primary measures of nutritional intervention, which plays a role in improving the nutritional status of the population (10). Dairy products possess emulsification and hydrophilicity characteristics, making them suitable for nutritional fortification with fat-soluble or water-soluble nutrients (11). Micronutrient fortification of dairy products is permitted in most countries for preschool children, and the most common fortified dairy food is milk powder (12). In combination with the current status of children's dietary nutrition and health in China, it is necessary to encourage children's dietary diversity. At the same time, the dairy products consumed by children can be synergistically fortified with vitamins, minerals, and other nutrients according to their dietary intake (13). In addition, the importance of polyunsaturated fatty acids and dietary fiber in children's nutrition and health has been confirmed (14, 15). Therefore, the use and addition of food ingredients or nutritional fortifiers beneficial to children's growth and development can be encouraged in dairy products.

In order to study the impact of dairy products on the dietary nutrition status of children, Jia x et al. utilized data from the China Health and Nutrition Survey 2015 (2015 CHNS) to perform a simulation study on children aged 3–8 years (16). The results showed that increasing daily consumption to the recommended amount (300 g/day) would reduce nutritional gaps, and formulated milk powder for children aged $\geq$3 years is a good food source to facilitate children in meeting their nutritional needs (16). However, the contribution of dietary supplements was not considered in this study. In fact, dietary supplements have significantly contributed to the intake of some minerals and vitamins in China. A previous survey showed that 41.1% of children aged 3–6 years consumed dietary supplements

in China, which was higher than that of children aged 7–12 years (17). Therefore, when assessing the impact of dairy products on preschool children's dietary nutritional adequacy, both food consumption and dietary supplement use should be evaluated simultaneously. In addition, the 2022 Chinese balanced diet pagoda for preschool children recommends consuming dairy products daily, equivalent to 350–500 g/day of liquid milk (7). It is also necessary to increase the dairy product levels in the simulation.

Based on the data from a cross-sectional dietary intake survey of infants and young children aged 0–6 years in China (DSIYC, 2018–2019), this study aims to evaluate the impact of dairy products on the dietary nutritional status of 676 preschool children (age: 3–6 years) through two scenarios. In scenario 1, individual intake of liquid milk equivalents was simulated and substituted with a corresponding volume of soymilk, cow's milk, or formulated milk powder for preschool children (FMP-PSC). In scenario 2, increasing the amount of cow's milk or FMP-PSC to bring each child's dairy intake to the recommended amount (350 g/day) was simulated. We hypothesized that the greatest improvements in nutrients of public health concern for preschool children would be observed when using FMP-PSC to simulate each scenario.

Materials and methods

Study population

The data of DSIYC from 2018 to 2019 were used in the analysis. First, two municipalities and 11 provinces, including Beijing, Shanghai, Guangdong, Sichuan, Yunnan, Fujian, Zhejiang, Jiangsu, Anhui, Hubei, Henan, Hebei, and Liaoning, were selected according to their geographical location, economic conditions, and annual live births. Then, the survey city was selected in accordance with the urban and rural areas of each region. Finally, according to the information provided by the maternal and child health center, preschool children were randomly recruited from each city. Based on the survey, we selected the effective dietary data of 676 preschool children aged 3–6 years, including 224 aged 3–4 years, 226 aged 4–5 years, and 226 aged 5–6 years.

Dietary data collection

The dietary intake of preschool children was assessed through the use of an online diary with reference to the food atlas, which was developed by our research group using three visual reference systems, namely, regularly placed food portions, the two-dimensional background coordinates and common objects known in daily life (18). A food list composed of 323 types of food and drink was integrated into a 4-day online diary (including 2 working days and 2 weekends) to record food and drink intake. The data were collected by third parties (Danone Open Science Research Center and Taylor Nelson Sofres). Similar to previous research methods (19, 20), in face-to-face interviews, trained interviewers asked parents to report all foods and drinks, condiments, and dietary supplements consumed by the preschool children.

Dietary data analysis

After the food was converted to the weight in its common state (i.e., 100% edible state and raw weight), the total daily intake of each kind of food was summed up. The individual components were recorded in the compound processed food, such as steamed stuffed buns, dumplings, wonton, steamed vermicelli roll, Chinese rice pudding, glutinous rice balls, hamburgers, pizza, and sandwiches. For example, in the chicken burger, bread, chicken, lettuce, and cheese were considered separately. The dairy products consumed were divided into 4 categories: liquid milk, milk powder, yogurt, and other dairy products (such as cheese, condensed milk, and milk tablets). The amounts of milk powder, yogurt, and other dairy foods were converted into their liquid milk equivalents in accordance with their protein composition. The total liquid milk equivalents were considered as the total intake of dairy products, and the proportion of preschool children who did not meet the recommended 350 g/day dairy intake in the 2022 balanced dietary pagoda for preschool children (**Supplementary Figure 1**) was calculated.

The energy and nutrient contents of each food were determined in accordance with the Chinese Food Composition Table (6th edition) (21). During the survey, the trade name of dietary supplements was recorded, and the nutrient content marked in the product manual was finally calculated together with the nutrient content from the dietary intake. According to the 2013 Chinese Dietary Reference Intakes (DRIs) (22), the intakes of most nutrients below the estimated average requirement (EAR) were perceived as inadequate, which included carbohydrate, protein, calcium, iron, zinc, iodine, vitamin A, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_6, vitamin B_9, vitamin B_{12}, vitamin C and vitamin D. Adequate intake (AI) was used to assess potassium inadequacy. Inadequate fiber intake was defined as the daily intake of <10 g/1,000 kcal energy. The upper limit of the acceptable macronutrient distribution ranges (AMDR) was applied to calculate the proportion of preschool children who consumed excessive fat.

Modeling scenarios

In scenario 1, the individual intake of liquid milk equivalents was simulated to be replaced with soymilk (model 1), cow's milk

(model 2), and FMP-PSC (Aptamil) (model 3) at a matching volume. In scenario 2, cow's milk (model 4) or FMP-PSC (model 5) was added so that each child's dairy intake reached the recommended amount (350 g/day). In both scenarios, the nutrient intakes and the proportion of children with nutritional inadequacy or surplus after simulation were compared with the actual reported data. Nutritional composition per 100 g of soymilk, cow's milk, and FMP-PSC used for simulation scenarios were shown in **Supplementary Table 1**.

Statistical analyses

The normality of the continuous variables was tested and almost all dietary data were determined to show non-normal distribution; accordingly, they were represented by P_{50} (P_{25}; P_{75}). Categorical variables were expressed as frequency (n) and percentage (%). The participants were grouped by age, and the differences in dairy intake among different age groups were compared by Chi-square test or Kruskal Wallis H test according to the data type. Wilcoxon matched-pairs signed rank test and McNemar paired Chi-square test were applied to compare the differences in the nutrient intake and the changes in the proportion of preschool children with inadequate or excessive nutrient intake before and after modeling, respectively. Kruskal-Wallis H test or Mann-Whitney U test was applied to compare the energy changes of the different models. All data were statistically analyzed using the SPSS software package version 26.0 (IBM, New York, NY, USA). The results were considered to be statistically significant at $P < 0.05$.

Results

Dairy intakes before simulation

The distribution of dairy intakes before simulation (from DSIYC, 2018–2019) can be found in **Table 1**. Over 4 days, 92.01% of 676 preschool children aged 36–72 months consumed dairy foods. The dairy foods with the largest number among children were liquid milk, followed by milk powder. The median daily liquid milk equivalent was 174 g, with 88.31% of children falling short of the recommended amount (350 g/day).

Although there was no statistical difference in the proportion of consumers of liquid milk, yogurt, and other dairy products among age groups, there was a statistical difference in milk powder consumption among age groups. Specifically, as children aged, the proportion of milk powder consumed decreased. Although the proportion of children in all age groups who consumed less than the recommended amounts of dairy foods was high and there was no statistically significant difference among the groups, it is worth noting that, the amount of liquid milk equivalent consumed by children per day decreased with age, and the difference among all age groups was statistically significant.

Total energy and macronutrient intakes after simulation

In scenario 1, after substituting the intake of liquid milk equivalents with soymilk (model 1), cow's milk (model 2) and FMP-PSC (model 3) by matching volumes, compared with the reported data, the energy intake of children in all three models was significantly decreased, especially in the replacement of soymilk. The energy changes among the three models showed statistical differences (**Table 2**). There were similar changes in the intakes of carbohydrate and fat in each model. The protein intakes of all three models were comparable to the reported intake. The dietary fiber intake increased significantly after replacing with soymilk and FMP-PSC. The DHA intake findings showed that after FMP-PSC simulation, its value was significantly higher than that of other models (**Table 3**).

In scenario 2, after increasing the amount of cow's milk (model 4) or FMP-PSC (model 5) to make the dairy intake of each child reach the recommended amount, compared to the reported intake, the energy intake of children in both models was significantly increased. The differences in energy between

TABLE 1 Dairy intakes before simulation.

Parameters	All (n = 676)	37∼48 months (n = 224)	49∼60 months (n = 226)	61∼72 months (n = 226)	P
Dairy consumption N (%)	622 (92.01%)	210 (93.75%)	207 (92.41%)	205 (91.52%)	0.473
Liquid milk N (%)	399 (59.02%)	122 (54.46%)	135 (59.73%)	142 (62.83%)	0.189
Milk powder N (%)	277 (40.98%)	112 (50.00%)	95 (42.04%)	70 (30.97%)	< 0.001
Yogurt N (%)	236 (34.91%)	76 (33.93%)	81 (35.84%)	79 (34.96%)	0.913
Other dairy foods N (%)	118 (18.97%)	44 (19.64%)	36 (15.93%)	38 (16.81%)	0.556
Liquid milk equivalents (g/d)*	174.00 (84.61, 255.70)	196.72 (99.38, 280.84)	180.63 (100.00, 250.09)	149.38 (75.00, 244.25)	0.029
Below dairy recommendation N (%)	597 (88.31%)	193 (86.16%)	198 (88.39%)	206 (91.96%)	0.237

*Data were expressed in quartiles; P_{50} (P_{25}, P_{75}).
$^{\Delta}$ P was assessed using the Chi-square test or Kruskal Wallis H test for the differences in dairy intake among different age groups.

TABLE 2 Total energy intake after simulation (n = 676) [P_{50} (P_{25}, P_{75})] (kcal/d).

Groups		Total energy	Changes of energy	P^{Δ}
Before simulation		993.99 (765.65, 1,256.99)	/	/
Scenario 1	Model 1	841.35 (657.73, 1,088.29)[a]	−70.28 (−187.38, −23.00)	<0.001
	Model 2	887.57 (690.99, 1,137.87)[bd]	−20.57 (−158.34, 0.00)	
	Model 3	911.78 (719.13, 1,162.83)[cef]	−0.16 (−129.96, 6.73)	
Scenario 2	Model 4	1,094.00 (874.92, 1,332.44)[g]	109.01 (65.27, 148.74)	<0.001
	Model 5	1,119.87 (906.53, 1,356.15)[hi]	139.02 (83.23, 189.68)	

Wilcoxon matched-pairs signed rank test was used to compare the differences in energy intake before and after modeling, respectively.
[a]Model 1 vs. Before simulation $P < 0.05$.
[b]Model 2 vs. Before simulation $P < 0.05$.
[c]Model 3 vs. Before simulation $P < 0.05$.
[d]Model 2 vs. Model 1 $P < 0.05$.
[e]Model 3 vs. Model 1 $P < 0.05$.
[f]Model 3 vs. Model 2 $P < 0.05$.
[g]Model 4 vs. Before simulation $P < 0.05$.
[h]Model 5 vs. Before simulation $P < 0.05$.
[i]Model 5 vs. Model 4 $P < 0.05$.
Model 1: The intake of liquid milk equivalents was replaced by soymilk at a matching volume.
Model 2: The intake of liquid milk equivalents was replaced by cow's milk at a matching volume.
Model 3: The intake of liquid milk equivalents was replaced by FMP-PSC at a matching volume.
Model 4: The amount of cow's milk was added to make the dairy intake of each child reach the recommended amount.
Model 5: The amount of FMP-PSC was added to make the dairy intake of each child reach the recommended amount.
$^{\Delta}$ P was assessed using the Kruskal-Wallis H test (in Scenario 1) or Mann-Whitney U test (in Scenario 2) for changes of energy after simulation of different models.

the two models were statistically significant (Table 2). The changes in carbohydrate, protein and fat intakes were shown to be similar to changes in energy consumption in both models, and the proportion of children with inadequate carbohydrate and protein intake decreased significantly. The intake of dietary fiber and DHA increased significantly after the addition of FMP-PSC, and their values were significantly higher than those after the addition of cow's milk (Table 3).

The intakes of carbohydrates, protein, fat, dietary fiber, and DHA by different age groups after simulation were shown in Supplementary Table 2, and the changes in these nutrients were similar to those of the entire age group.

Table 4 displayed the surplus energy contribution from fat (%E) of the 49–60-month-old and the 61–72-month-old groups. The energy contribution from fat increased slightly in all five models when compared with the reported intake in both age groups. In both scenario 1 and scenario 2, cow's milk simulation (model 2 and model 4) showed that the proportion of children with excessive energy contribution from fat was higher than that of other simulation groups.

Mineral intakes after simulation

In scenario 1, although the calcium intake of children was significantly decreased following the substitution of soymilk (model 1), it was significantly increased after the simulation with cow's milk (model 2), or FMP-PSC (model 3). Especially in the latter, the proportion of children with inadequate calcium intake decreased from 91.57 to 83.14%. Children's iron and zinc intake changed similarly following the simulation, and only the replacement of FMP-PSC increased their intake. In addition, no improvement in inadequate iodine and potassium intake was seen as compared to the reported intake (Table 5).

In scenario 2, adding cow's milk (model 4) or FMP-PSC milk (model 5) significantly increased calcium intake, and the proportion of children with inadequate calcium intake in the total population decreased by 16.13 and 27.22%, respectively. The addition of FMP-PSC significantly increased iron and zinc intake while decreasing the proportion of children with inadequate intake, which was 18.64 and 35.35%, respectively. Similar effects were also found in the addition of cow's milk, but there was less improvement. The addition of cow's milk and FMP-PSC both significantly increased children's intake of iodine and potassium while tend to decrease the proportion of children with inadequate intake (Table 5).

The intakes of calcium, iron, zinc, iodine, and potassium by different age groups after simulation were shown in Supplementary Table 4 and the changes in these nutrients were similar to those of the whole age group.

Vitamin intakes after simulation

In scenario 1, only the replacement of FMP-PSC (model 3) increased the intakes of vitamin A, vitamin B_1, vitamin B_{12}, vitamin C and vitamin D, while the opposite results were observed following the replacement of soymilk (model 1) or cow's milk (model 2). The intakes of vitamin B_2 and vitamin B_6 were decreased following soymilk substitution, while their intakes were slightly increased after simulation with cow's milk

TABLE 3 Macronutrient intakes after simulation (n = 676).

Macronutrients	Groups		P_{50} (P_{25}, P_{75})	N (%)
Carbohydrate (g/d)	Before simulation		109.81 (83.05, 145.60)	388 (57.40%)
	Scenario 1	Model 1	100.18 (73.69, 133.98)[a]	444 (65.68%)[a]
		Model 2	104.02 (78.80, 137.97)[bd]	422 (62.43%)[bd]
		Model 3	109.98 (83.28, 144.39)[cef]	392 (57.99%)[ef]
	Scenario 2	Model 4	116.38 (89.74, 149.97)[g]	359 (53.11%)[g]
		Model 5	122.19 (95.56, 156.60)[hi]	330 (48.82%)[hi]
Protein (g/d)	Before simulation		32.65 (25.27, 43.05)	161 (23.82%)
	Scenario 1	Model 1	33.21 (25.69, 43.41)[a]	159 (23.52%)
		Model 2	33.21 (25.69, 43.41)[b]	159 (23.52%)
		Model 3	32.99 (25.57, 43.14)[cef]	161 (23.82%)
	Scenario 2	Model 4	38.46 (31.17, 47.53)[g]	65 (9.62%)[g]
		Model 5	38.34 (31.02, 47.40)[hi]	66 (9.76%)[h]
Fat (g/d)	Before simulation		37.87 (29.81, 48.28)	/
	Scenario 1	Model 1	34.31 (26.78, 43.96)[a]	/
		Model 2	37.29 (29.00, 47.34)[bd]	/
		Model 3	37.16 (28.90, 46.98)[cef]	/
	Scenario 2	Model 4	43.60 (36.50, 53.35)[g]	/
		Model 5	43.46 (36.31, 53.19)[hi]	/
Dietary fiber (g/d)	Before simulation		3.94 (2.79, 5.95)	668 (98.82%)
	Scenario 1	Model 1	6.03 (4.30, 8.36)[a]	581 (85.95%)[a]
		Model 2	3.93 (2.79, 5.95)[bd]	664 (98.22%)[d]
		Model 3	5.91 (4.24, 8.18)[cef]	636 (94.08%)[cef]
	Scenario 2	Model 4	3.94 (2.79, 5.95)[g]	671 (99.26%)
		Model 5	6.10 (4.70, 7.82)[hi]	658 (97.34%)[hi]
DHA (mg/d)	Before simulation		16.17 (8.89, 26.30)	/
	Scenario 1	Model 1	12.97 (7.36, 23.19)[a]	/
		Model 2	12.97 (7.32, 23.02)[b]	/
		Model 3	28.39 (17.27, 42.88)[cef]	/
	Scenario 2	Model 4	16.17 (8.89, 26.30)	/
		Model 5	32.31 (25.18, 40.76)[hi]	/

Wilcoxon matched-pairs signed rank test and McNemar paired Chi-square test were used to compare the differences in nutrient intake and the changes in the proportion of preschool children with inadequate nutrient intake before and after modeling, respectively.
[a]Model 1 vs. Before simulation $P < 0.05$.
[b]Model 2 vs. Before simulation $P < 0.05$.
[c]Model 3 vs. Before simulation $P < 0.05$.
[d]Model 2 vs. Model 1 $P < 0.05$.
[e]Model 3 vs. Model 1 $P < 0.05$.
[f]Model 3 vs. Model 2 $P < 0.05$.
[g]Model 4 vs. Before simulation $P < 0.05$.
[h]Model 5 vs. Before simulation $P < 0.05$.
[i]Model 5 vs. Model 4 $P < 0.05$.
Model 1: The intake of liquid milk equivalents was replaced by soymilk at a matching volume.
Model 2: The intake of liquid milk equivalents was replaced by cow's milk at a matching volume.
Model 3: The intake of liquid milk equivalents was replaced by FMP-PSC at a matching volume.
Model 4: The amount of cow's milk was added to make the dairy intake of each child reach the recommended amount.
Model 5: The amount of FMP-PSC was added to make the dairy intake of each child reach the recommended amount.

or FMP-PSC. In the models of soymilk and cow's milk, the improvement of inadequate vitamin B_3 intake was limited, but it was improved in the FMP-PSC model. After the simulation, Children's vitamin B_9 intake improved significantly, especially when soymilk was replaced. In the dairy food simulation, FMP-PSC improved on inadequate vitamin B_9 intake better than cow's milk, and the proportion of the total population with inadequate vitamin B_9 intake decreased by 1.63 and 13.32%, respectively (Table 6).

In scenario 2, increasing FMP-PSC (model 5) significantly raised the intakes of vitamin A, vitamin B_1, vitamin B_{12}, and vitamin C, and decreased the proportion of children with inadequate intakes, which were 33.58, 8.58, 20.41, and 6.95%, respectively. Although the addition of cow's milk had

TABLE 4 Energy contribution from fat after simulation.

Nutrient	Groups		49–60 months (n = 226)		61–72 months (n = 226)	
			P_{50} (P_{25}, P_{75})	N (%)	P_{50} (P_{25}, P_{75})	N (%)
Fat (%E)	Before simulation		37.68 (32.23, 41.77)	189 (83.63%)	35.78 (30.08, 40.80)	170 (75.22%)
	Scenario 1	Model 1	38.66 (34.74, 42.61)	208 (92.04%)[a]	37.64 (33.36, 42.65)[a]	196 (86.73%)
		Model 2	39.78 (36.05, 43.36)[bd]	210 (92.92%)[b]	38.71 (34.23, 43.63)[bd]	204 (90.27%)
		Model 3	38.36 (34.92, 42.37)[ef]	208 (92.04%)[c]	37.50 (33.54, 42.02)[cef]	198 (87.61%)
	Scenario 2	Model 4	39.71 (34.47, 43.05)[g]	205 (90.71%)[g]	38.20 (32.98, 43.15)[g]	200 (88.50%)[g]
		Model 5	38.39 (33.47, 41.65)[hi]	197 (87.17%)[hi]	36.92 (32.28, 40.92)[hi]	194 (85.84%)[hi]

The upper limit of the acceptable macronutrient distribution ranges was used to calculate the proportion of preschool children with excessive intake of fat. Wilcoxon matched-pairs signed rank test and McNemar paired Chi-square test were used to compare the differences in nutrient intake and the changes in the proportion of preschool children with excessive nutrient intake before and after modeling, respectively.

[a]Model 1 vs. Before simulation $P < 0.05$.

[b]Model 2 vs. Before simulation $P < 0.05$.

[c]Model 3 vs. Before simulation $P < 0.05$.

[d]Model 2 vs. Model 1 $P < 0.05$.

[e]Model 3 vs. Model 1 $P < 0.05$.

[f]Model 3 vs. Model 2 $P < 0.05$.

[g]Model 4 vs. Before simulation $P < 0.05$.

[h]Model 5 vs. Before simulation $P < 0.05$.

[i]Model 5 vs. Model 4 $P < 0.05$.

Model 1: The intake of liquid milk equivalents was replaced by soymilk at a matching volume.

Model 2: The intake of liquid milk equivalents was replaced by cow's milk at a matching volume.

Model 3: The intake of liquid milk equivalents was replaced by FMP-PSC at a matching volume.

Model 4: The amount of cow's milk was added to make the dairy intake of each child reach the recommended amount.

Model 5: The amount of FMP-PSC was added to make the dairy intake of each child reach the recommended amount.

comparable effects (model 4), there was less improvement. The inadequate intake of vitamin B_2 and vitamin B_6 was significantly improved, and the effect of adding cow's milk was greater than that of adding FMP-PSC. The improvement of inadequate intake of vitamin B_3 and vitamin D was limited in the model of cow's milk, but this situation improved in the FMP-PSC model. Furthermore, FMP-PSC improved on inadequate vitamin B_9 intake better than cow's milk, reducing the proportion of children with inadequate vitamin B_9 intake by 19.53% (**Table 6**).

The intakes of vitamin A, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_6, vitamin B_9, vitamin B_{12}, vitamin C, and vitamin D by different age groups after simulation were shown in Supplementary Table 4 and the changes in these nutrients were similar to those of the whole age group.

Discussion

The DSIYC, 2018–2019, on which this simulation study was based, is a cross-sectional survey of Chinese children aged 0–6 years conducted in multiple regions of China from 2018 to 2019. It can be seen from the results that the percentage of consumption and amounts of dairy products consumed have increased in recent years, but the consumption of dairy products by preschool children remains low. According to CHNS 2015, 97.6% of children did not meet the recommended 300 g/day of dairy foods (16). We found that 88.31% of preschool children in this study did not meet the recommended amount (350 g/day). As a result, more research into the impact of dairy products on the dietary nutritional status of preschool children is required.

This study also looked at the trends in dairy consumption among age groups. The results showed that the intake of total dairy products decreased significantly with age, which was consistent with the findings of other studies in China and other countries (23, 24). However, the results of this study's change in dairy types with age differed from those of other countries. In western countries, for example, a study in Germany found that with the increase of age (3.5–18.5 years), the type of dairy products changed from liquid to solid, and the intake of fermented dairy products increased (24). However, in this study, liquid milk was the most consumed dairy item, followed by milk powder, while the consumption of fermented dairy products (such as yogurt and cheese) was lower. Only the proportion of children consuming milk powder, not liquid milk or fermented dairy products, declined considerably with age. It is worth mentioning that the formula milk powder is 86.64% of the milk powder consumed by children aged 3–6 in this study. As a result, formula milk powder played a role in improving preschool children's dietary nutrition, and this study compared the effects of liquid milk and FMP-PSC on children's dietary nutrition by simulating two scenarios. Soymilk, unlike popular milk in western countries, is a food with Chinese characteristics that is widely popular in China (25). Therefore, in scenario 1, we included a simulation that replaced soymilk for all dairy products in the reported data to compare the effects of soymilk, cow's milk, and FMP-PSC on children's dietary nutrition.

TABLE 5 Mineral intakes after simulation (n = 676).

Minerals	Groups		P_{50} (P_{25}, P_{75})	N (%)
Calcium (mg/d)	Before simulation		311.82 (214.98, 425.66)	619 (91.57%)
	Scenario 1	Model 1	148.30 (100.34, 216.65)[a]	674 (99.70%)[a]
		Model 2	324.63 (220.71, 451.34)[bd]	613 (90.68%)[d]
		Model 3	366.49 (242.29, 519.44)[cef]	562 (83.14%)[cef]
	Scenario 2	Model 4	502.06 (450.54, 574.62)[g]	510 (75.44%)[g]
		Model 5	559.27 (506.83, 622.25)[hi]	435 (64.35%)[hi]
Iron (mg/d)	Before simulation		9.19 (6.97, 12.02)	143 (21.15%)
	Scenario 1	Model 1	9.13 (6.82, 11.82)	152 (22.49%)
		Model 2	8.91 (6.67, 11.55)[bd]	164 (24.26%)[bd]
		Model 3	10.63 (8.13, 13.73)[cef]	94 (13.91%)[cef]
	Scenario 2	Model 4	9.69 (7.46, 12.41)[g]	107 (15.83%)[g]
		Model 5	11.42 (9.27, 14.11)[hi]	17 (2.51%)[hi]
Zinc (mg/d)	Before simulation		4.80 (3.59, 6.36)	254 (37.57%)
	Scenario 1	Model 1	4.38 (3.34, 5.70)[a]	295 (43.64%)[a]
		Model 2	4.66 (3.52, 6.02)[bd]	260 (38.46%)[d]
		Model 3	5.97 (4.41, 7.81)[cef]	149 (22.04%)[cef]
	Scenario 2	Model 4	5.51 (4.49, 6.94)[g]	124 (18.34%)[g]
		Model 5	6.96 (6.02, 8.24)[hi]	15 (2.22%)[hi]
Iodine (μg/d)	Before simulation		43.22 (16.10, 590.62)	394 (58.28%)
	Scenario 1	Model 1	35.95 (14.29, 592.21)[a]	400 (59.17%)
		Model 2	35.43 (13.75, 591.95)[bd]	401 (59.32%)
		Model 3	44.78 (22.29, 597.77)[cef]	383 (56.66%)[cef]
	Scenario 2	Model 4	46.58 (20.28, 593.94)[g]	389 (57.54%)
		Model 5	52.71 (30.01, 604.03)[hi]	371 (54.88%)[hi]
Potassium (mg/d)	Before simulation		824.26 (606.15, 1,134.74)	500 (73.96%)
	Scenario 1	Model 1	840.84 (630.50, 1,129.34)[a]	474 (70.12%)[a]
		Model 2	828.99 (622.01, 1,106.02)[d]	488 (72.19%)[d]
		Model 3	772.71 (571.04, 1,030.04)[cef]	526 (77.81%)[cef]
	Scenario 2	Model 4	1,031.31 (831.35, 1,295.77)[g]	379 (56.07%)[g]
		Model 5	962.59 (753.87, 1,225.69)[hi]	422 (62.43%)[hi]

The intakes of calcium, iron, zinc, and iodine below the estimated average requirement were perceived as inadequate, while the adequate intake was used for evaluating potassium inadequacy. Wilcoxon matched-pairs signed rank test and McNemar paired Chi-square test were used to compare the differences in nutrient intake and the changes in the proportion of preschool children with inadequate nutrient intake before and after modeling, respectively.

[a]Model 1 vs. Before simulation $P < 0.05$.

[b]Model 2 vs. Before simulation $P < 0.05$.

[c]Model 3 vs. Before simulation $P < 0.05$.

[d]Model 2 vs. Model 1 $P < 0.05$.

[e]Model 3 vs. Model 1 $P < 0.05$.

[f]Model 3 vs. Model 2 $P < 0.05$.

[g]Model 4 vs. Before simulation $P < 0.05$.

[h]Model 5 vs. Before simulation $P < 0.05$.

[i]Model 5 vs. Model 4 $P < 0.05$.

Model 1: The intake of liquid milk equivalents was replaced by soymilk at a matching volume.

Model 2: The intake of liquid milk equivalents was replaced by cow's milk at a matching volume.

Model 3: The intake of liquid milk equivalents was replaced by FMP-PSC at a matching volume.

Model 4: The amount of cow's milk was added to make the dairy intake of each child reach the recommended amount.

Model 5: The amount of FMP-PSC was added to make the dairy intake of each child reach the recommended amount.

Previous studies have shown that dairy products aid in the adequate intake of nutrients for children and adolescents. According to the data from the 2007 Australian National Children's Nutrition and Physical Activity Survey (2–16 years), consuming milk was associated with increased calcium, phosphorus, magnesium, potassium, and iodine intakes when compared to those who did not drink milk (26). According to National Health and Nutrition Examination Survey 2001–2016 data, American children who drank yogurt took in more calcium, magnesium, potassium, sodium, vitamin B_{12}, and vitamin D than non-consumers (27). Data from the South East Asian Nutrition Survey (0.5–12 years) showed that dairy

TABLE 6 Vitamin intakes after simulation (n = 676).

Vitamins	Groups		P_{50} (P_{25}, P_{75})	N (%)
Vitamin A (μg RAE/d)	Before simulation		211.57 (148.37, 293.54)	429 (63.46%)
	Scenario 1	Model 1	180.04 (123.94, 250.17)[a]	495 (73.22%)[a]
		Model 2	197.40 (136.50, 269.02)[bd]	451 (66.72%)[bd]
		Model 3	224.62 (160.35, 314.27)[cef]	371 (54.88%)[cef]
	Scenario 2	Model 4	251.52 (202.28, 326.33)[g]	321 (47.49%)[g]
		Model 5	286.74 (235.73, 354.90)[hi]	202 (29.88%)[hi]
Vitamin B_1 (mg/d)	Before simulation		0.33 (0.24, 0.46)	596 (88.17%)
	Scenario 1	Model 1	0.31 (0.23, 0.42)[a]	621 (91.86%)[a]
		Model 2	0.33 (0.24, 0.44)[bd]	611 (90.38%)[bd]
		Model 3	0.37 (0.27, 0.49)[cef]	573 (84.76%)[cef]
	Scenario 2	Model 4	0.38 (0.31, 0.51)[g]	566 (83.73%)[g]
		Model 5	0.43 (0.35, 0.54)[hi]	538 (79.59%)[hi]
Vitamin B_2 (mg/d)	Before simulation		0.53 (0.36, 0.73)	367 (54.29%)
	Scenario 1	Model 1	0.38 (0.28, 0.50)[a]	563 (83.28%)[a]
		Model 2	0.59 (0.43, 0.80)[bd]	315 (46.60%)[bd]
		Model 3	0.54 (0.40, 0.73)[cef]	359 (53.11%)[ef]
	Scenario 2	Model 4	0.78 (0.67, 0.94)[g]	62 (9.17%)[g]
		Model 5	0.74 (0.63, 0.90)[hi]	106 (15.68%)[hi]
Vitamin B_3 (mg NE/d)	Before simulation		6.78 (5.12, 9.45)	249 (36.83%)
	Scenario 1	Model 1	6.89 (5.17, 9.51)[a]	244 (36.09%)
		Model 2	6.80 (5.08, 9.42)[bd]	251 (37.13%)[d]
		Model 3	7.31 (5.58, 10.05)[cef]	212 (31.36%)[cef]
	Scenario 2	Model 4	6.99 (5.24, 9.66)[g]	229 (33.88%)[g]
		Model 5	7.52 (5.70, 10.16)[hi]	188 (27.81%)[hi]
Vitamin B_6 (mg/d)	Before simulation		0.71 (0.50, 0.93)	213 (31.51%)
	Scenario 1	Model 1	0.69 (0.49, 0.91)[a]	237 (35.06%)[a]
		Model 2	0.72 (0.52, 0.94)[bd]	213 (31.51%)[d]
		Model 3	0.72 (0.53, 0.95)[cef]	202 (29.88%)[cef]
	Scenario 2	Model 4	0.77 (0.58, 1.00)[g]	160 (23.67%)[g]
		Model 5	0.77 (0.59, 1.01)[hi]	150 (22.19%)[hi]
Vitamin B_9 (μg DFE/d)	Before simulation		115.94 (84.86, 156.99)	465 (68.79%)
	Scenario 1	Model 1	182.27 (132.55, 242.33)[a]	202 (29.88%)[a]
		Model 2	118.08 (86.40, 161.04)[bd]	454 (67.16%)[bd]
		Model 3	137.73 (102.85, 181.64)[cef]	375 (55.47%)[cef]
	Scenario 2	Model 4	125.21 (94.79, 167.29)[g]	437 (64.64%)[g]
		Model 5	144.45 (113.62, 187.05)[hi]	333 (49.26%)[hi]
Vitamin B_{12} (μg/d)	Before simulation		1.63 (1.04, 2.54)	140 (20.71%)
	Scenario 1	Model 1	1.29 (0.88, 2.13)[a]	187 (27.66%)[a]
		Model 2	1.59 (1.03, 2.56)[d]	124 (18.34%)[bd]
		Model 3	1.89 (1.25, 2.93)[cef]	85 (12.57%)[cef]
	Scenario 2	Model 4	1.96 (1.49, 2.74)[g]	22 (3.25%)[g]
		Model 5	2.38 (1.96, 3.10)[hi]	2 (0.30%)[hi]
Vitamin C (mg/d)	Before simulation		42.47 (22.56, 69.87)	302 (44.67%)
	Scenario 1	Model 1	36.65 (19.42, 65.67)[a]	344 (50.89%)[a]
		Model 2	38.51 (20.53, 67.65)[bd]	333 (49.26%)[bd]
		Model 3	44.22 (26.14, 73.91)[cef]	289 (42.75%)[cef]
	Scenario 2	Model 4	44.24 (24.40, 72.04)[g]	297 (43.93%)
		Model 5	49.64 (30.63, 77.03)[hi]	255 (37.72%)[hi]

(Continued)

TABLE 6 (Continued)

Vitamins	Groups		P_{50} (P_{25}, P_{75})	N (%)
Vitamin D (μg/d)	Before simulation		0.00 (0.00, 1.82)	666 (98.52%)
	Scenario 1	Model 1	0.00 (0.00, 0.00)[a]	670 (99.11%)
		Model 2	0.00 (0.00, 0.00)[b]	670 (99.11%)
		Model 3	1.25 (0.61, 1.96)[cef]	667 (98.67%)
	Scenario 2	Model 4	0.00 (0.00, 1.82)[g]	666 (98.52%)
		Model 5	2.12 (1.42, 2.86)[hi]	665 (98.37%)

RAE, retinol activity equivalent; NE, nicotinic acid equivalent; DFE, dietary folate equivalent. The intakes of vitamins below the estimated average requirement were perceived as inadequate. Wilcoxon matched-pairs signed rank test and McNemar paired Chi-square test were used to compare the differences in nutrient intake and the changes in the proportion of preschool children with inadequate nutrient intake before and after modeling, respectively.

[a]Model 1 vs. Before simulation $P < 0.05$.

[b]Model 2 vs. Before simulation $P < 0.05$.

[c]Model 3 vs. Before simulation $P < 0.05$.

[d]Model 2 vs. Model 1 $P < 0.05$.

[e]Model 3 vs. Model 1 $P < 0.05$.

[f]Model 3 vs. Model 2 $P < 0.05$.

[g]Model 4 vs. Before simulation $P < 0.05$.

[h]Model 5 vs. Before simulation $P < 0.05$.

[i]Model 5 vs. Model 4 $P < 0.05$.

Model 1: The intake of liquid milk equivalents was replaced by soymilk at a matching volume.

Model 2: The intake of liquid milk equivalents was replaced by cow's milk at a matching volume.

Model 3: The intake of liquid milk equivalents was replaced by FMP-PSC at a matching volume.

Model 4: The amount of cow's milk was added to make the dairy intake of each child reach the recommended amount.

Model 5: The amount of FMP-PSC was added to make the dairy intake of each child reach the recommended amount.

as part of a daily diet supported a healthy vitamin A and vitamin D status (28). Our study yielded comparable findings. In scenario 1, only the intake of dietary fiber, potassium, and vitamin B_9 was significantly increased after replacing all dairy products in the reported data with soymilk. While the intake of calcium, vitamin B_2, vitamin B_3, vitamin B_6, and vitamin B_9 was significantly higher after replacing all dairy products in the reported data with cow's milk or FMP-PSC; and the impact of FMP-PSC was significantly better than that of cow's milk in increasing the intake of calcium, vitamin B_3, vitamin B_6, and vitamin B_9. Other simulation studies on children's dairy products had similar results (16, 29). Interestingly, our study found that replacing all dairy products in the reported data with cow's milk considerably reduced children's intake of dietary fiber, DHA, iron, zinc, iodine, vitamin A, vitamin B_1, vitamin B_{12}, vitamin C, and vitamin D. However, when all dairy products in the reported data were replaced with FMP-PSC, the intake of these nutrients rose significantly. This situation may be explained by the reported data's high proportion of formula milk powder consumed by preschool children. More and more Chinese families take FMP-PSC as a part of children's daily diet to meet their nutritional needs for growth and development. The composition of cow's milk and FMP-PSC is different. On top of the nutritional content of cow's milk, including high quality protein and high calcium content, FMP-PSC is further fortified with several micronutrients and functional ingredients, which play an important role in preventing children from nutrient deficiency and maintaining their health (30, 31).

The adequacy of children's dairy intake is positively correlated with higher nutritional intake, nutritional adequacy, and dietary quality. Dairy products are important for bone health and linear growth in childhood. A previous study indicated that promoting dairy consumption may be a feasible and effective measure to improve the linear growth of Chinese preschool children (32). In addition, many studies support the inverse association between the amount of dairy intake and the indicators of obesity, dental caries, and hypertension in children and adolescents (33–35). Therefore, this study simulated dairy products achieving the recommended amount after adding liquid milk or FMP-PSC. The results showed that adding cow's milk or FMP-PSC significantly increased the intake levels of protein and some key micronutrients, including calcium, iron, zinc, iodine, potassium, vitamin A, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_6, vitamin B_9, vitamin B_{12}, and vitamin C. Among these micronutrients, except for potassium and vitamin B_2, the improvement effect of FMP-PSC on inadequate intakes of micronutrients was significantly better than that of cow's milk. This result is similar to the previous simulation study based on the dietary survey data of children (1–8 years) in China (16). In addition, due to the lack of dietary fiber and DHA in cow's milk, the addition of cow's milk did not significantly increase the intake of these two nutrients as the addition of FMP-PSC, which is also the advantage of FMP-PSC over cow's milk.

However, based on the results of this study, we must admit that there are some limitations. First, though food fortification, such as FMP-PSC is a good way to improve vitamin D intake, the study shows the prevalence of insufficient vitamin D intake remains high. Since vitamin D status is closely linked to lifestyle, in future research, lifestyle factors such as outdoor activity time and sunscreen application should be considered to better assess vitamin D status. Moreover, the simulation scenarios of this study only used liquid milk equivalent to determine

the dietary nutritional status of various models. In fact, the consumption patterns of dairy products are diversified, and a larger sample size will be required to evaluate more complex simulation scenarios, such as the combination of different types of dairy products (liquid milk, yogurt, cheese, condensed milk, etc.) and FMP-YCF.

In conclusion, consuming dairy products below the recommended level leads to inadequate nutrient intake in preschool children. Since food preferences and dietary behaviors develop in the preschool period, determining the most effective dietary behaviors to prevent the decline of dairy intake in preschool children is critical. Our simulation study showed that replacing dairy foods with FMP-PSC at matching volume (scenario 1) is better than replacing with soymilk or cow's milk in increasing most nutrient intakes in preschool children and adding FMP-PSC to make the intake of dairy products per child reach the recommended amount (scenario 2) can bring the intake of most nutrients of preschool children more in line with the recommendations when compared to cow's milk. Therefore, to guide the scientific consumption of dairy products, correct nutrition information should be given to parents and preschool children. When necessary, the use and addition of dairy products with food ingredients or nutritional fortifiers can be encouraged. Furthermore, for optimal nutritional intakes of preschool children, in addition to the dietary behavior modification of dairy consumption, a multi-faceted approach that includes a diversified balanced diet and the use of dietary supplements (such as vitamin D) is required.

Data availability statement

The original contributions presented in this study are included in the article/**Supplementary material**, further inquiries can be directed to the corresponding author.

Author contributions

ZW and YD: conceptualization and design of the work. YD, ZX, GL, YZ, JY, and MF: analysis and interpretation of the work. YD, FH, and GL: writing—original draft preparation. YD, ZX, FH, JY, and ZW: writing—review and editing. ZW: supervision and funding acquisition. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2022.1081495/full#supplementary-material

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Prevalence and correlates of overweight and obesity among under-five children in Egypt

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Background: Evidence suggests that Egypt, a country in North Africa, has a significant number of children at serious risk of excess body weight. Yet, there is a dearth of studies on overweight and obesity among children under 5 years in the country. This study examined the prevalence and correlates of overweight and obesity among under-five children in Egypt.

Methods: Data were retrieved from the latest (2008 and 2014) Egypt Demographic and Health Surveys (EDHS). A total of 42,568 children under 5 years were included. The prevalence of overweight and obesity was described using proportions whereas the factors associated with the prevalence were examined using logistic regression.

Results: Of the 42,568 children under 5 years, about one in every six (17%) were overweight or obese. Children aged 19–37 months, those with birth weights >4 kg, those given large portions of protein foods (eggs and meat), and those whose mothers were in the rich wealth quintile had significant risks of overweight or obesity.

Conclusion: Overweight and obesity are highly prevalent among children under 5 years in Egypt. Interventions developed to address these two overnutrition indicators in Egypt need to consider variations in risk factors across age, birth weight, food types and portions, and maternal wealth status.

KEYWORDS

child overnutrition in Egypt, overweight and obesity, under-five children, risk factors, excess body weight, overnutrition, Demographic and Health Survey

Introduction

Overweight and obesity defined as an abnormal or excessive build-up of body fats that might harm one's health (1), are emerging public health concerns in Africa (2). The impact of overweight and obesity is even more significant when it occurs in children as it puts them at increased risk of both early and long-term breathing problems, musculoskeletal diseases, hypertension, diabetes, stroke, insulin resistance, some cancers, and adult obesity (3, 4). Also, obesity in childhood is linked to a higher risk of mental health issues, impairment, and even death (5).

Globally, there are about 41 million children under 5 years reported to be either overweight or obese as of 2018 (6). A growing body of evidence shows that the current majority of obese or overweight children are in developing countries, where the rate of increase is more than 30 percent higher than in industrialized countries (7). Overweight and obesity in children are on the rise, largely, due to significant changes in dietary and physical activity behavior (8). Thus, technological advancement has made it easier to perform daily physical activities; hence increasing sedentary lifestyles and reducing physical activities (9). In recent years, more children are also spending more time indoors and are likely to spend much time watching television or playing video games, which makes them less active and gain weight as a result (10). Moreover, dietary patterns have changed from traditional healthy diets largely composed of fruits and vegetables to energy-dense foods which are high in calories, fats and sugars (11). The World Health Organization recommends that to avoid the risk of excess body weight, infants should be breastfed exclusively during the first 6 months of their lives, should be breastfed continuously until at least 2 years of age, breast milk should be complemented with a variety of nutritious foods, salt or sugar should not be added to foods, food portions should contain at least 400 g or five portions of fruits and vegetables per day, and fat intake should be <30% of total energy intake (12).

Evidence shows that genetic or family characteristics are also factors associated with risk of overweight and obesity (13). Research indicates a possibility of a person inheriting about 40% of body type from parents (14). Additionally, emerging evidence suggests that socio-demographic factors, such as parental wealth status and place of residence have a significant impact on the likelihood of childhood overweight or obesity (15). Importantly, overweight or obesity resulting from socio-demographic factors are known to be modifiable compared to genetic factors (13). This idea of modifiable and non-modifiable risk factors associated with overweight and obesity is critical to developing appropriate interventions for reducing childhood overnutrition.

One of the regions in the world facing a high risk of overnutrition is North Africa. Studies show a rising trend in childhood overweight and obesity in North Africa, especially, in Egypt, with the prevalence higher than most countries in the Middle East and Sub-Saharan Africa (15, 16). A study among school-going children in Sohag, Egypt found that 17% of the participants were overweight and 15% were obese (3). Behera, a suburb of Egypt found as high as 18% of overweight and obesity among primary school children in 2019 (17). Although several community-based evidence shows a high prevalence of overweight and obesity among children under-5 years in Egypt, childhood overnutrition is under-studied in Egypt with most studies focusing on adults and adolescents (3, 17). In view of this significant gap, we examined the prevalence and correlates of overweight and obesity in Egypt. Findings from this study are critical to developing tailored interventions aimed at addressing overnutrition in the country and even beyond.

Abbreviations: EDHS, Egypt Demographic and Health Survey; ICF, International classification of functioning, disability and Health; USAID, United States Agency for International Development; WHO, World health Organization.

Methods

Overview

Since 1980, several surveys have been carried out in Egypt to obtain data from the community on the current health situation including a series of Demographic and Health Surveys (DHS) of which the 2014 Egypt Demographic and Health Survey (EDHS) is the most recent (18). The 2014 EDHS is of special importance as it is the latest and first national health survey since 2008. The initial results of the 2014 EDHS show that key maternal and child health indicators, including antenatal care coverage and medical assistance at delivery, have improved. However, the survey also documents several critical challenges, particularly relating to fertility and family planning (18). The findings of the 2014 EDHS together with the service-based data are very important for measuring the achievements of health and population programs. The 2014 EDHS was conducted under the jurisdiction of the Ministry of Health and Population (18). International classification of functioning, disability and Health (ICF) provided technical support for the survey through the DHS program. The DHS Program is sponsored by the United States Agency for International Development (USAID) to assist countries worldwide to obtain information on key population and health indicators (18). USAID/Cairo also provided funding to support the implementation of the survey. UNICEF and UNFPA also contributed funding to the survey. The 2014 EDHS survey design has two components; a survey of ever-married women aged 15–49 years and a special Health Issues survey to obtain updated information on other critical health problems facing Egypt (18). The data are publicly available at http://measuredhs.org. Details on the approach used in gathering the data including the sampling methods can be found in the EDHS reports (18, 19).

Data

This study was based on the latest [2014 (EGKR61DT.ZIP) and 2008 (EGKR61DT.ZIP)] children's data drawn from Egypt's Demographic and Health Surveys (EDHS). The EDHS children's data contained information on children's nutrition and women aged 15–49 years. Approximately, 42,589 children under five were sampled to partake in the study (18, 19).

Variable description

A total of 18 variables were included in the study, and these variables were categorized into three: (i) Child variables which included age (0–18 months = infant, 19–37 months = toddlers, 38–59 months = children), sex (males and females), birth weight (<2.5 kg = low birth weight, 2.5–4.0 kg = Normal weight, 4.1 and above = overweight), place of residence, access to a bicycle, access to vehicle, child given carbohydrate foods, child given protein foods, child given fatty foods and child given fruits, (ii) Maternal variables including maternal age (11–19 years = adolescent, 20–28 years = young adult, 29 years and above = adult), educational level, wealth index, maternal BMI (when BMI < 25 kg/m^2 = Not overweight/obese, when BMI > 25 kg/m^2 = Overweight/obese) (20), marital status (married = currently married, widow+divorce+never married = not married), postnatal visit, and current work status), (iii) Husband/partner's educational level (Table 1).

Body mass index (BMI) was measured and calculated using the WHO's new standard for child growth (21). The new standard is an international standard for assessing nutritional status, physical growth, and child development from birth to the 5th year. Overnutrition (overweight and obesity) was calculated in standard deviation using the *z*-score ≥ 2. Childhood overweight/obese was defined as *z*-scores ≥ 2. Also, the mother's overweight/obese was considered a BMI > 25 kg/m^2 (21). To determine the actual child BMI value in the datasets, the measure was divided by 100.

With regards to other covariates, we assessed child food consumption by these questions: "Did you give your child eggs and meat (protein food)?" "Did you give your child any other fruits?" and "Did you give your child oil, fats, and butter products?" The responses to these questions are described in Table 1.

TABLE 1 Variable categorization and description.

Variables	Coding used for the analysis
Outcome	
Overweight/obese	1 = *z*-score ≥ 2
Not overweight/obese	0 = *z*-score <2
Independent	
Age of child	1 = 0–18 months, 2 = 19–37 months, 3 = 38+ months
Sex of child	1 = Male, 2 = Female
Birth weight	1 = <2.5 kg, 2 = 2.5–4.0 kg, 3 = 4.1+ kg
Access to bicycle	1 = No 2 = Yes
Access to car	1 = No 2 = Yes
Child given carbohydrate food	1 = No 2 = Yes
Child given protein food	0 = No, 1 = Yes
Child given fatty food	0 = No, 1 = Yes
Child given fruit	0 = No, 1 = Yes
Maternal age at first birth	1 = 11–19 years, 2 = 20–28 years, 3 = 29+ years
Education level	0 = No formal education, 1 = Primary level education, 2 = Secondary level education, 3 = Higher level education
Place of residence	1 = Urban, 2 = Rural
Wealth index	1 = Poor, 2 = Middle, 3 = Rich
Mother's BMI	1 = Overweight/obese, 2 = Not overweight/obese
Marital status	1 = Not married, 2 = Married
Antenatal visit during pregnancy	0 = No, 1 = Yes
Postnatal visit	0 = No, 1 = Yes
Father's educational level	0 = No formal education, 1 = Primary level education, 2 = Secondary level education, 3 = Higher level education
Current work status	1= Not working, 2 = Working

Data analysis

Descriptive statistics including frequencies and percentages were performed. Aside from the descriptive statistics multivariate analyses (logistic regression) were computed in the final model to observe associations between the independent and dependent variables. Based on recommendations from empirical literature (15), the logistic regression analysis was set at a 95% confidence interval and adjusted for other covariates which included: age of child, sex of child, birthweight, place of residence, access to car, access to bicycle, child given carbohydrate, child given protein food, child given fatty foods, child given fruits, maternal age at first birth, mother's educational level, wealth index, mother's BMI, antenatal visit, postnatal visit, father's educational level, and current work status. Logistic regression was used because the outcome variable was categorized into two, Overweight/obese = 1 and Not overweight/obese = 2. The analysis was performed using Stata/SE 14.

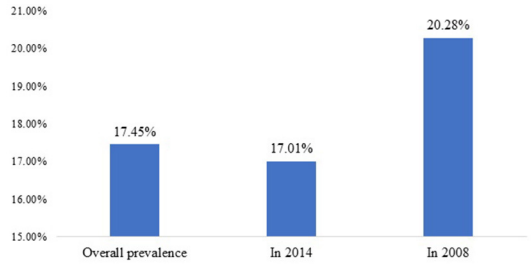

FIGURE 1
Prevalence of coexistence of overweight and obesity in Egypt, 2008 and 2014.

TABLE 2 Participant characteristics.

Variable	*N* = 42,568 (%)	Weighted % (CI)
Child variables		
Age of child (months)		
0–18 months	14, 568 (34.25)	34.08 (0.33–0.35)
19–37 months	13,642 (32.01)	32.01 (0.31–0.33)
38+ months	14,358 (33.74)	33.91 (0.33–0.35)
Sex of child		
Male	22,057 (51.82)	52.20 (0.51–0.53)
Female	20,511 (48.18)	47.80 (0.47–0.49)
Birth weight		
<2.5 kg	3,326 (14.08)	14.67 (0.14–0.16)
2.5–4.0 kg	19,662 (83.24)	82.90 (0.82–0.84)
>4.0 kg	633 (2.68)	2.42 (0.02–0.03)
Place of residence		
Urban	16,771 (39.40)	32.47 (0.31–0.34)
Rural	25,797 (60.60)	67.52 (0.66–0.69)
Access to bicycle		
No	37,299 (92.72)	92.84 (0.92–0.93)
Yes	2,927 (7.28)	7.16 (0.07–0.08)
Access to car		
No	36,500 (90.75)	92.53 (0.91–0.93)
Yes	3,719 (9.25)	7.47 (0.07–0.08)
Child given carbohydrate foods		
No	32,448 (95.67)	95.95 (0.95–0.96)
Yes	1,469 (4.33)	4.04 (0.04–0.05)
Child given protein foods		
No	23,669 (69.66)	69.50 (0.68–0.71)
Yes	10,307 (30.34)	30.49 (0.29–0.32)
Child given fatty foods		
No	3,808 (44.19)	43.93 (0.42–0.46)
Yes	4,809 (55.81)	56.49 (0.54–0.58)
Child given fruits		
No	31,008 (91.29)	91.12 (0.90–0.92)
Yes	2,957 (8.71)	8.88 (0.08–0.10)
Mothers' variables		
Maternal age at first birth		
11–19	13,246 (31.12)	31.54 (0.30–0.32)
20–28	26,916 (63.23)	63.13 (0.62–0.64)
29+	2,406 (5.65)	5.32 (0.05–0.06)
Mother's education level		
No education	8,440 (19.83)	19.87 (0.19–0.21)
Primary	3,804 (8.94)	9.01 (0.08–0.10)
Secondary	23,811 (55.94)	55.93 (0.55–0.57)
Higher	6,513 (15.30)	15.19 (0.14–0.16)
Wealth index		
Poor	16,637 (39.08)	38.30 (0.37–0.40)
Middle	8,844 (20.78)	24.00 (0.23–0.25)
Rich	17,087 (40.14)	37.69 (0.36–0.39)
Mother's BMI		
Not overweight/obese	28,637 (67.79)	65.08 (0.64–0.66)
Overweight/obese	13,605 (32.21)	34.92 (0.34–0.36)
Mother's marital status		
Not married	684 (1.61)	1.60 (0.01–0.02)
Married/cohabiting	41,884 (98.39)	98.40 (0.98–0.99)
Antenatal visit		
No	6,115 (14.37)	13.98 (0.13–0.15)
Yes	36,435 (85.63)	86.01 (0.85–0.87)
Postnatal visit		
No	22,673 (69.05)	67.78 (0.67–0.69)
Yes	10,164 (30.95)	32.21 (0.31–0.33)
Fathers' variables		
Father's education level		
No education	5,723 (13.45)	13.67 (0.13–0.14)
Primary	5,836 (13.71)	14.00 (0.13–0.15)
Secondary	23,940 (56.25)	55.58 (0.54–0.57)
Higher	7,060 (16.59)	16.74 (0.16–0.18)
Current work status		
Not working	37,240 (87.58)	87.55 (0.87–0.88)
Working	5,275 (12.41)	12.44 (0.12–0.13)

CI, Confidence interval; N, Total number of respondents.

Results

Socio-demographic characteristics of participants

A total of 42,568 children under 5 years were included in the study. Of these, there was a similar proportion in terms of age. A little more than one-third (34%) and (33%) were between 0 and 18 months and above 38 months, respectively. With regards to sex, the majority (52%) were males and the remaining 48% were females. Children who were born with low birth weights were ∼15% whereas the majority (83%) weighed between 2.5 and 4.0 kg at birth, with only 2% weighing above 4.0 kg. Most (68%) of the children lived in rural areas whereas the remaining 32% were in urban areas. Less than 10% had access to a bicycle while the majority (93%) had access to a car. In terms of food consumption, about 4 percent were commonly given carbohydrate foods whereas more than a quarter (30%) were commonly given protein foods. More than half (56.4%) were commonly consuming fatty foods whereas less than a quarter (8.8%) were commonly consuming fruits (Table 2).

For mothers' sociodemographic characteristics, more than a quarter (32%) were adolescents (11–19 years), the majority (63%) were young adults (20–28 years), and the remaining 5% were considered adults (29 years and above). Most mothers (56%) had attained secondary level education, one-fifth (20%) had no formal education, 15% had higher education, and the least (9%) had primary education. For wealth index, there was a similar proportions between poor and rich mothers, with each having ∼38% and the remaining 24% being among those in the middle class in terms of wealth. Mothers who were overweight or obese were 34% whereas 65% were neither overweight nor obese. The vast majority (98%) were married and most of them (68%) did not visit a postnatal clinic after birth, whereas 32% attended postnatal clinics after birth. In terms of a child's father's educational level, more than half (56%) had secondary level education, followed by higher education (17%), primary education (14%), and no formal education (13%). Most (88%) of the fathers were not working at the time of the survey whereas 12% were gainfully employed (Table 2).

Prevalence of overweight and obesity in Egypt

As shown in Figure 1, the overall prevalence of childhood overweight and obesity was ∼17% (CI = 0.17–0.19). In 2014 alone, the prevalence rate was 16.9% (CI = 0.16–0.18), and in 2008 the prevalence was 20.3% (CI = 0.20–0.23). Although the prevalence of overnutrition is still high as of 2014, the findings show a slight decrease in childhood overweight and obesity between the two survey periods.

Factors associated with overweight and obesity among under-five children in Egypt

There was a significant association between childhood overweight or obesity and the following factors: children aged 19 to 37 months (OR = 1.39, CI = 1.25–1.55, p = 0.001), children in rural residence (OR = 0.83, CI = 0.73–0.94, p = 0.003), children given protein foods (OR = 1.22, CI = 1.10–1.36, p = 0.001), children given fatty foods (OR = 1.45, CI = 1.26–1.67, p = 0.001), children given fruits (OR = 1.27, CI = 1.09–1.49, p = 0.001), children belonging to mothers aged 29 years or more (OR = 1.22, CI = 1.01–1.49, p = 0.04), children belonging to rich mothers (OR = 1.29, CI = 1.14–1.46, p = 0.001), children belonging to mothers who attended postnatal healthcare (OR = 1.12, CI = 1.02–1.24, p = 0.020), and children belonging to fathers who were gainfully employed (OR = 1.21, CI = 1.07–1.37, p = 0.002; Table 3).

The model was then adjusted to confirm the associations between the identified explanatory variables and the childhood undernutrition indicators (overweight and obesity). We found that overweight and obesity were significantly associated with children aged 19 to 37 months (AOR = 1.32, CI = 1.05–1.65, p = 0.015), children with a birthweight of 4.1 kg and above (AOR = 2.45, CI = 1.25–4.81, p = 0.010), children given protein foods (AOR = 1.29, CI = 1.02–1.63, p = 0.029), and rich mothers (AOR = 2.19, CI = 1.54–3.11, p = 0.001; Table 3).

These results imply that children aged 19–37 months had 1.32 higher odds of becoming overweight or obese compared to those younger and older (<19 and >37 months). Those who weighed more than 4.1 kg had 2.45 times higher odds of being overweight or obese compared to those who weighed lesser. Children who significantly consumed protein foods had 1.29 higher odds of becoming overweight or obese relative to those who consumed other food types. With regards to maternal factors, those belonging to rich mothers had 2.19 higher odds of becoming overweight or obese compared to those belonging to poor mothers and mothers with an average level of wealth (Table 3).

Discussion

This study aimed to examine the prevalence and correlates of overweight and obesity among children under 5 years in Egypt. The findings revealed that the overall prevalence of overweight and obesity was approximately 17% which corresponds with previous community-based studies in Egypt which found an overnutrition prevalence rate ranging from 15 to 18% (3, 22). Our reported prevalence rate for Egypt is nearly twice the average rate for the world, which is estimated at 8.6%, indicating a serious childhood overnutrition problem in Egypt and the need for prompt actions to reduce this significant health burden (8).

The study also found several socio-demographic factors significantly associated with overweight and obesity among children under 5 years in Egypt. Notably, the childhood overnutrition indicators were significantly associated with children aged between 19 and 37 months, children with birthweights of 4.1 kg and above, children given large amounts of protein foods, and children belonging to rich mothers. The findings that children within the age bracket of 19–37 months had higher odds of developing childhood overweight or obesity is quite difficult to explain as there is a lack of literature on this topic (23). However, limited evidence shows that toddlers around that age bracket often engage in emotional eating behavior and often use food as a form of compensation or a soothing intervention when they feel upset which may put them at serious risk of being overweight or obese (24). Additionally, parenting styles and feeding practices may contribute to overweight or obesity among such infants (25–28). A systematic review has noted strong associations between indulgent or uninvolved parenting style and high childhood BMI whereas an authoritative parenting style was reported to be associated

TABLE 3 Logistic regression of associations between explanatory variables and overnutrition.

Variable	Unadjusted		Adjusted	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Child variables				
Age of child (months)				
0–18 months	**Ref.**		**Ref.**	
19–37 months	1.39 (1.25–1.55)	***0.000***	1.32 (1.05–1.65)	***0.015***
38+ months	1.01 (0.89–1.14)	*0.904*	0.99 (0.74–1.31)	*0.925*
Sex of child				
Male	**Ref.**		**Ref.**	
Female	0.96 (0.88–1.04)	*0.364*	1.04 (0.85–1.28)	*0.705*
Birth weight				
<2.5 kg	**Ref.**		**Ref.**	
2.5–4.0 kg	0.99 (0.83–1.18)	*0.951*	1.19 (0.82–1.71)	*0.360*
4.1 + kg	1.20 (0.8–1.75)	*0.336*	2.45 (1.25–4.81)	***0.010***
Place of residence				
Urban	**Ref.**		**Ref.**	
Rural	0.83 (0.73–0.94)	***0.003***	0.97 (0.75–1.25)	*0.801*
Access to bicycle				
No	**Ref.**		**Ref.**	
Yes	0.86 (0.72–1.03)	*0.103*	0.88 (0.59–1.30)	*0.514*
Access to car				
No	**Ref.**		**Ref.**	
Yes	0.99 (0.84–1.17)	*0.932*	1.23 (0.97–1.58)	*0.087*
Child given carbohydrate foods				
No	**Ref.**		**Ref.**	
Yes	0.96 (0.76–1.21)	*0.753*	0.92 (0.72–1.18)	*0.601*
Child given protein foods (eggs and meats)				
No	**Ref.**		**Ref.**	
Yes	1.22 (1.10–1.36)	***0.000***	1.29 (1.02–1.63)	***0.029***
Child given fatty foods				
No	**Ref.**		**Ref.**	
Yes	1.45 (1.26–1.67)	***0.000***	0.92 (0.73–1.17)	*0.524*
Child given fruits				
No	**Ref.**		**Ref.**	
Yes	1.27 (1.09–1.49)	***0.003***	1.22 (0.88–1.69)	*0.23*
Mothers' variables				
Maternal age at first birth				
11–19	**Ref.**		**Ref.**	
20–28	1.01 (0.91–1.13)	*0.80*	1.15 (0.89–1.49)	*0.28*
29+	1.22 (1.01–1.49)	***0.04***	1.53 (0.92–2.54)	*0.10*
Mother's education level				
No education	**Ref.**		**Ref.**	
Primary	1.22 (1.03–1.46)	***0.021***	1.42 (0.87–2.31)	*0.16*
Secondary	1.24 (1.10–1.39)	***0.000***	1.31 (0.88–1.93)	*0.18*
Higher	1.33 (1.14–1.57)	***0.000***	1.14 (0.66–2.00)	*0.63*

(Continued)

TABLE 3 (Continued)

Variable	Unadjusted		Adjusted	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Wealth index				
Poor	**Ref.**		**Ref.**	
Middle	1.02 (0.89–1.16)	*0.810*	2.02 (1.43–2.85)	***0.000***
Rich	1.29 (1.14–1.46)	***0.000***	2.19 (1.54–3.11)	***0.000***
Mother's BMI				
Not overweight/obese	**Ref.**		**Ref.**	
Overweight/obese	1.03 (0.94–1.15)	*0.464*	0.98 (0.75–1.26)	*0.851*
Marital status				
Not married	**Ref.**		**Ref.**	
Married	1.12 (0.74–1.67)	*0.593*	1.50 (0.52–4.33)	*0.448*
Antenatal visit				
No	**Ref.**		**Ref.**	
Yes	1.03 (0.91–1.16)	*0.609*	1.24 (0.91–1.69)	*0.175*
Postnatal visit				
No	**Ref.**		**Ref.**	
Yes	1.12 (1.02–1.24)	***0.020***	0.87 (0.67–1.12)	*0.052*
Fathers' variables				
Father's education level				
No education	**Ref.**		**Ref.**	
Primary	1.18 (0.99–1.42)	*0.478*	1.19 (0.74–1.92)	*0.474*
Secondary	1.05 (0.91–1.21)	*0.481*	1.13 (0.76–1.79)	*0.482*
Higher	1.23 (1.03–1.46)	*0.479*	1.06 (0.63–1.80)	*0.813*
Current work status				
Not working	**Ref.**		**Ref.**	
Working	1.21 (1.07–1.37)	***0.002***	1.08 (0.78–1.50)	*0.630*

CI, Confidence interval; Ref, reference; OR, Odds Ratio.
p-value < 0.05 considered statistically significant.
Italicized and bold values are significant p-values.

with a healthy BMI (28). Indulgent parenting style means parenting styles based on a combination of low demandingness, high responsiveness to a child's needs, and few rules; indulgent parenting style implies parenting styles associated with both low demandingness and low responsiveness; and authoritative parenting styles are parenting styles associated with a high level of demandingness, numerous rules, and high responsiveness to the needs of a child (28). Regarding feeding practices, the study further emphasized that authoritative feeding styles are associated with healthy BMIs whereas indulgent feeding styles are associated with a higher risk of overweight or obesity (28). Nevertheless, the systematic review and other available literature on parenting feeding practices were not decomposed according to age categories, and therefore, an in-depth exploration of the interplay of childhood age and parental feeding practices with overweight or obesity will be timely and important (25–28).

Consistent with previous studies (29, 30), we found that children who weighed 4.1 kg or higher at birth were more likely to experience childhood overweight or obesity. In line with our findings, a study in Sweden has indicated that males and females with birth weights above three standard deviation scores had higher risks of obesity, ranging from 2.46 to 1.85, respectively (30). In contrast, biological evidence shows that children with low birth weight have a higher concentration of plasma leptin which increases their obesity risks (31). Several previous studies have also indicated that low birth weights are associated with higher BMI *z*-scores and higher odds of obesity (32, 33). Casey et al. (33) for instance, reported an increase in obesity in a cohort of low-birth-weight preterm infants and reported a proportional increase in obesity from 2.3% at the age of 3 years to 6.1% prevalence by the age of 5 years. Together, these findings demonstrate an interesting paradox in terms of associations between birth weights and risks of overweight or obesity which may be attributed to differences in samples and confounding variables, such as variations in residence. To adequately understand the impact of birth weights on risks

of overweight or obesity, it will be important to employ a longitudinal approach whereby the same cohort of infants will be studied over time. Nevertheless, our study contributes to the growing evidence on associations between high birth weights and risks of being overweight or obese in subsequent years of a child's life.

With regards to food consumption, children who consumed protein foods such as meat and eggs had a greater risk of overweight and obesity. This finding is in line with several previous studies (3, 34). A plausible reason for this outcome is that a high intake of protein foods is likely to lead to excess storage of body fats which eventually leads to a higher risk of overweight or obesity (24, 26). It needs to be however acknowledged that the assessment of food intake in the DHS data were limited to "yes" and "no" responses, hence this finding should be taken with caution. Consistent with previous studies (27, 28, 35), we also found that children belonging to wealthy mothers had a higher risk of overweight and obesity. This is probably because children in rich households may be exposed to high-calorie foods and sedentary lifestyles which puts them at risk of overweight and obesity (36, 37).

While taking due caution in making policy suggestions based on findings from this cross-sectional data, our findings which are based on over 40,000 under-five children provide a comprehensive and important "wake-up" call to policymakers and health advocates about the need to pay close attention to childhood overnutrition in Egypt. Particularly, interventions aiming to reduce childhood undernutrition need to be cautious of the possibilities of causing overnutrition after the implementation of food intake interventions. Additionally, our findings indicate that the growing overnutrition problem in Egypt (North Africa) can be effectively reduced if attention is paid to modifiable risk factors, such as sedentariness and overfeeding of toddlers with high protein foods, especially, by wealthy mothers (12). Supportive interventions are important in shaping people's choices, especially, in choosing healthier foods for their children and engaging in regular physical activity (12). At the individual level, parents can limit the provision of foods high in proteins to toddlers and increase the consumption of fruit and vegetables (38, 39). We believe that these factors are critical in promoting optimal health for children aged under 5 years in Egypt and even beyond.

Recent studies on overweight and obesity in Africa have indicated a potential double burden of undernutrition and overnutrition in the continent (40, 41). However, the previous studies have been largely focused on adult populations in Sub-Saharan Africa with limited studies focusing on children in North Africa, although anecdotal evidence shows that many North African countries have a potentially high prevalence of childhood overnutrition. Using Egypt as a case study, we have successfully reported the prevalence of overweight and obesity among children under-5 years and the risk factors associated with these overnutrition indicators. The potential burden of childhood overnutrition in Africa has received much attention in recent years. Modifiable risk factors may be important contributors to overnutrition, and this study is one of the early research projects examining this emerging problem for early interventions. Findings from this study provide useful calls for researchers, health promoters, and policymakers to consider seriously the emerging problem of childhood overnutrition in Egypt and North Africa.

Limitations of the study

By examining the prevalence and factors associated with childhood overnutrition in Egypt, this study provides a timely empirical contribution to the literature examining whether childhood overnutrition is indeed a growing problem in North Africa.

Although this study makes a noteworthy contribution to the literature on childhood overnutrition including the pooling of large samples of children under-5 years from two standard EDHS, and therefore increasing the statistical power, some limitations can be observed. First, the data is limited to ever-married women with children under 5 years which may limit the generalizability of the findings. The study is cross-sectional and therefore we were unable to make causal inferences. Also, some variables were self-reported which may be subject to recall and social desirability biases. There was evidence of missing responses for some variables which made data cleaning and validation complicated. Also, almost all the variables were used in the regression analysis, and this is likely to contribute to over-adjustment bias. However, all the variables were important possible risk factors for childhood overweight or obesity in Egypt. Although we used the latest EDHS data, the available data were gathered in 2008 and 2014 which are quite old and may lack some currency. Therefore, the prevalence rates should be taken cautiously. Lastly, food consumption frequency, timing, and portions were not captured in the data (i.e., the timing, portions, and frequency of protein intake, fat intake, fruit intake, or carbohydrate intake were not captured, and the questions were asked based on self-observational measures). Responses to dietary intake were limited to "yes" or "no" answers, making it hard to examine less healthy dietary intake. While this might have impacted the significance of the findings on food intake, the current findings provide an important indication of the need to pay close attention to food behavior among under-five children in Egypt.

Conclusion

We conclude that overnutrition (overweight and obesity) is highly prevalent among children under 5 years in Egypt. Approximately one in every six children (17%) included in

our sample were either overweight or obese. We also found that a child's age (19–37 months), birth weight (>4 kg), protein consumption levels, and mothers' wealth status were significantly associated with the likelihood of overweight and obesity among children under-5 years in Egypt. This is a significant public health concern as overweight or obesity increases risk of numerous health issues, such as cardiovascular diseases, musculoskeletal diseases, diabetes, stroke, and some cancers (12). These findings adequately address the objectives of this study and indicate the need for early and urgent strategies to mitigate childhood overnutrition in Egypt.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: http://dhsprogram.com/data/available-datasets.cf.

Ethics statement

Ethical approval was not sought for this study since our analysis was based on publicly available data. However, the DHS reports that both written and verbal informed consent were obtained from all participants. Before the commencement of the survey, ethical clearance was sought and all ethical guidelines governing the use of human subjects were strictly adhered to and methods were carried out in accordance with the relevant guidelines and regulations by the Declaration of Helsinki.

Author contributions

IA conceived the study, reviewed the analyses, and supervised the entire study. EO conducted the multilevel analysis. EO and IA drafted and critically reviewed the manuscript. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Parent's food literacy and adolescents nutrition literacy influence household's food security and adolescent's malnutrition and anemia: Findings from a national representative cross sectional study

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Introduction: Food and nutrition literacy are widely fundamental to improve the food security and reduce the double burden of malnutrition and iron deficiency in low- and middle-income countries.

Objectives: This study aimed (1) to assess the nutrition literacy (NL) of Lebanese adolescents and their parents' food literacy (FL), (2) to investigate the impacts of adolescents' NL and parental FL on (a) the household food security, (b) the adolescents' self-reported food security, and (c) the adolescents' nutrition status with a focus on malnutrition and anemia.

Methods: A national representative sample of 450 parent–adolescent dyads [parents: mean age ± standard deviation (SD) = 46.0 ± 7.0, mothers: 59.0%; adolescents: mean age ± SD = 15.0 ± 3.0, girls: 54.6%] were interviewed. Anthropometric and blood hemoglobin measurements were performed for adolescents. The Arab Family Food Security Scale and the Adolescent-Level Food Security Scale were used.

Results: Around 45.0% of the adolescents were nutritionally illiterate, and nearly half (47.8%) of parents had poor FL. Around 68.2 and 54.0% of the households and adolescents were food insecure, respectively. Moreover, 6.7, 4.7, 32.2, and 16.7% of the adolescents were stunted, thin, overweight/obese, and anemic, respectively. Poor parental FL increased the risk of household food insecurity (FI) by 2.7 times, $p < 0.001$. Adolescents' nutrition illiteracy increased their FI risk by 60.0% ($p = 0.02$). The number of offspring, household

income, crowding status, and participants' residence also influenced the percentage of FI and malnutrition prevalence among households and adolescents.

Conclusion: Improvements in FL and NL are promising to mitigate FI malnutrition in Lebanon.

KEYWORDS

food literacy, nutrition literacy, food insecurity, malnutrition, anemia, parents-adolescents dyads

Introduction

Food and nutrition literacy are nowadays considered as the bridge between food, nutrition, and well-being of communities in low-and middle-income countries (1). Moreover, it can serve as a fundamental step toward the capacity building to effectively use nutrition/food knowledge and skills, to meet specifically the adolescent's current and future health (1). Many definitions and conceptualizations of food/nutrition literacy are available; however, a widely-cited definition describes food literacy as a "collection of interrelated knowledge, skills, and behaviours required to plan, manage, select, prepare, and eat foods to meet needs and determine food intake." Furthermore, food literacy is "the staging that empowers individuals, households, communities, and nations to protect diet quality through change and support dietary resilience over time" (2). Some studies have characterized food literacy as the ability to search and understand nutrition-related information (3). (On the other hand, Lee, C.-K., and colleagues (4) defines nutrition literacy (NL) as a set of individual and context-related characteristics which allow adherence to a healthy diet that respects the guidelines on proper nutrition and recommendations. It concerns also the dietary performance, which reflects the competence of healthy eating patterns. A connection between the two concepts of FL and NL has been well documented frequently where both highlighted that food behaviors, skills, and knowledge cannot be separated because they are part of the same construct that is FNL (1–4). Exploring the status of NL in the early years of life, particularly during adolescence, is crucial and may aid in the adaptation of sustainable nutrition interventions (5). Adolescents are more prone to dietary vulnerabilities because they are going through a nutrition-sensitive phase of rapid growth and development (6). According to many solid evidences, NL has appeared as a critical factor in promoting and maintaining healthy dietary practices among adolescents, including food label use (7), higher dietary diversity (8), and nutrient intake adequacy (8). In addition, a higher prevalence of overweight and obesity was observed among nutritionally-illiterate adolescents (9). Not only improving nutrition outcomes but advocating for better FL and NL could help build resilience against food insecurity (FI) (10). FI is the state of being unable to access a sufficient quantity and quality of food (11). The four pillars of food security are (1) food availability; (2) food access; (3) food utilization; (4) stability of these three pillars over time (11). Of them, the utilization pillar encompasses FL skills and knowledge, which determines how the individual store, prepare and cook food (12). Food illiteracy may impede the adequate utilization of the available food and worsens the food security status even for wealthy communities (12). Begley et al. showed that households experiencing FI typically have worse levels of FL, manifested by low cooking self-efficacy, and unfavorable food purchasing habits (10). As well, Khorramrouz accentuates that there is a negative relationship between children's NL and their food security status (13). These lessons are to be considered in Lebanon, where FI has become inescapable for almost all Lebanese households (14–16). The Lebanese people are struggling to recover from the economic distress they face daily in the marketplace and when gathering with their families for meals.. Based on the above, this study aims to: (1) to assess the nutrition literacy (NL) of Lebanese adolescents and their parents' food literacy (FL), (2) to investigate the impacts of adolescents' NL and parental FL on (a) the household food security, (b) the adolescents' self-reported food security (c) and the adolescents' nutrition status with focus on malnutrition and anemia.

Materials and methods

Study design and participants' recruitment

This was a cross-sectional study including a representative sample of Lebanese parent-adolescent dyad, conducted from mid-March to mid-July 2022. Households were recruited using the stratified cluster sampling. The clusters were the eight Lebanese governorates (Mount Lebanon, Beirut, South Lebanon, North Lebanon, Akkar, Beqaa, Baalbeck-Hermel, and Nabatieh). Within each governorate, households were recruited using a probability proportional to size sampling technique. A single population formula was used to determine the sample size $n = [p\ (1 - p)] * [(Z_{\alpha/2})^2/(e)^2]$, where n is the sample size, Z $(\alpha/2)$ is the reliability coefficient of standard error at a 5% level of significance = 1.96, $p = 0.05$, and e refers to

the level of standard error tolerated (5%) (17). Thus, it was determined that 400 parent-adolescent dyads are an adequate sample size to ensure sufficient power for statistical analyses. After accounting for a 10% non-response rate, 450 parent-adolescent dyads were included in our final sample. This sample size is sufficient to ensure appropriate power for statistical analyses based on the statistics of the central Administration of Statistics in Lebanon (18).

Inclusion and exclusion criteria

A total number of 495 healthy adolescents, from both genders and aged 10–19 years old were recruited. Adolescents who were using iron dietary supplements, and donated blood in the month preceding the assessment were excluded from the study. In addition, only one adolescent child from each household was enrolled in the study. Parents with Lebanese nationality only and aged 18–64 years old were recruited (Refer to **Figure 1**).

Instruments and measures

Using a validated and well-designed questionnaire (19), the following information were collected from participants: (i) parents: age, gender, residency, marital status, the number of children the parent has, education level, occupation status, family monthly income (and if they experienced a recent decline in the income), the number of co-residents in the home, and the number of rooms; (ii) adolescents: date of birth, gender, residency, primary caregiver, whether currently working, education level, school type, and whether the adolescent receives nutrition education in their schools.

Adolescents' nutrition literacy

The adolescent's NL status was assessed using a valid 22-items scale: The Adolescent Nutrition Literacy Scale (ANLS) (20). This questionnaire was translated from a Turkish study to Arabic language. It was revised and translated by experts. ANLS evaluated three components of NL: Functional NL (FNL), Interactive NL (INL), and Critical NL (CNL). FNL reflects the capacity to comprehend nutrition concepts (21). INL refers to the communication skills required to receive nutrition information (21). CNL reflects the ability to critically analyze, evaluate and apply nutrition information (21). Each question in the ANLS has a score ranging from 0 to 5 (5-points Likert scale: strongly disagree to strongly agree). The questionnaire has an overall score range from 22 to 110 (a higher score indicates better NL). Adolescents' NL was considered poor or adequate based on the median scores (TNL: 68.0; FNL = 21.0; INL = 18.0; CNL = 30.0).

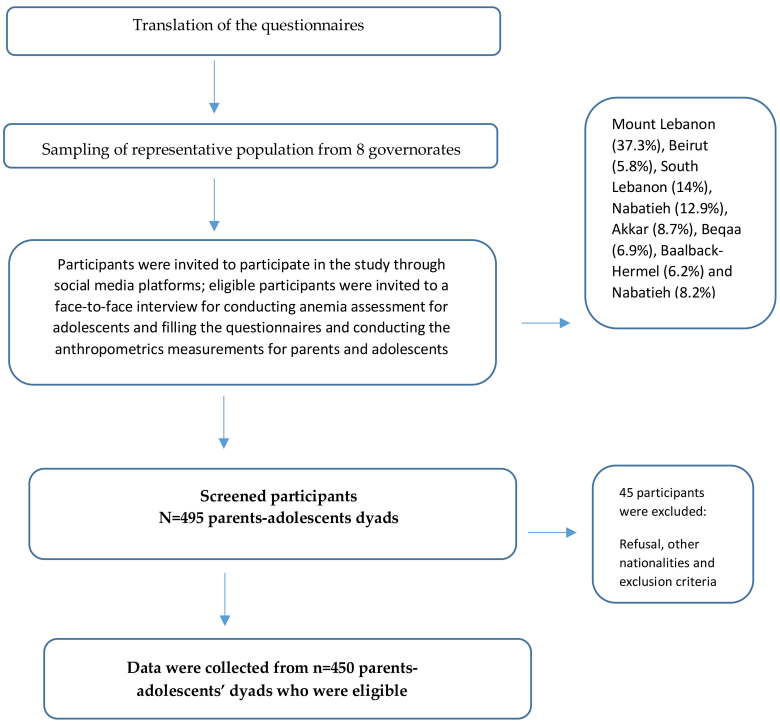

FIGURE 1
Flow diagram of the recruitment process in the current study.

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TABLE 1 Demographic and socioeconomic characteristics of parent participants and the household food security status.

	Overall (*N* = 450)		Females (*n* = 266)		Males (*n* = 184)		
	Mean	SD	Mean	SD	Mean	SD	*P*-value
Age in years	46.0	7.0	47.0	7.0	46.0	7.0	<0.001**
	N	%	*N*	%	*N*	%	
Adulthood stage							<0.001**
Early middle adulthood (30–45 years old)	230	51.0	158	59.4	72	39.1	
Late middle adulthood (46–64 years old)	220	49.0	108	40.6	112	60.9	
Area of residency							<0.001**
Mount Lebanon	168	37.3	80	32.5	88	43.1	
Beirut	26	5.8	19	7.7	7	3.4	
South Lebanon	63	14.0	46	18.7	17	8.3	
North Lebanon	58	12.9	36	14.6	22	10.8	
Akkar	39	8.7	24	9.8	15	7.4	
Beqaa	31	6.9	18	7.3	13	6.4	
Baalbeck-Hermel	28	6.2	10	4.1	18	8.8	
Nabatieh	37	8.2	13	5.3	24	11.8	
Weight status							0.11
Underweight	8	1.8	7	2.6	1	0.5	
Normal weight	218	48.4	128	48.1	90	48.9	
Overweight	146	32.4	79	29.7	67	36.4	
Obese	78	17.3	52	19.5	26	14.1	
Marital status							0.76
Married	431	95.8	254	95.5	177	96.2	
Divorced	9	2.0	5	1.9	4	2.2	
Widowed	10	2.2	7	2.6	3	1.6	
Number of children the parent has							0.42
One child	34	7.6	17	6.4	17	9.2	
2–3 children	243	54.0	142	53.4	101	54.9	
More than 3 children	173	38.4	107	40.2	66	35.9	
Highest education level							0.001*
No formal education	35	7.8	11	4.1	24	13.0	
School education level	292	64.9	174	65.4	118	64.1	
University education level	123	27.3	81	30.5	42	22.8	
Having current occupation							<0.001**
Yes	228	50.7	71	26.7	157	85.3	
No	222	49.3	195	73.3	27	14.7	
Monthly income of the family							0.13
None	35	7.8	25	9.4	10	5.4	
Less than 1.5 million LBP	67	14.9	33	12.4	34	18.5	
≥1.5 million LBP	294	65.3	171	64.3	123	66.8	

(Continued)

TABLE 1 (Continued)

	Overall (N = 450)		Females (n = 266)		Males (n = 184)		
	Mean	SD	Mean	SD	Mean	SD	P-value
≤300 USD	36	8.0	24	9.0	12	6.5	
More than 300 USD	18	4.0	13	4.9	5	2.7	
The household has experienced a recent decline in the monthly income							0.34
No	352	78.2	204	58.0	148	42.0	
Yes	98	21.8	62	63.3	36	36.7	
Household crowding status[a]							
Not crowded	248	55.1	159	59.8	89	48.4	0.04*
Crowded	202	44.9	107	40.2	95	51.6	
Household food security status							0.35
Food-secure	143	31.8	80	30.1	63	34.2	
Food-insecure	308	68.2	186	69.9	121	65.8	

[a]Determined based on the calculated crowding index (CI) (CI = number of persons in home/number of rooms excluding the kitchen and bathroom). CI ≤ 1 (no crowding); CI > 1 (crowding); *significant at p-value < 0.05 for the χ^2 test; **significant at p-value < 0.001 for the χ^2 test.

Parent's food literacy

A valid 12-item "short food literacy questionnaire 'SFLQ' (21) was used to evaluate parent's FL". This questionnaire was translated from a Swiss study to Arabic language. It was revised and translated by experts. Respondents answered via four- or five-point Likert scales. The questionnaire had a score ranging from 7 to 52. A higher score suggests better food literacy. The median score of 31.0 was used to categorize parents into having poor food literacy or adequate food literacy (22).

Household and adolescents' self-reported food security

The Arab Family Food Security Scale (AFFSS) (23), and a self-reported adolescent-level-food security scale (24) were used. These valid scales classified adolescents and their households as being either "food secure" or "foodinsecure."

Parents and adolescents' nutrition status

Parents and adolescents' body weight was measured to the nearest 0.1 kg while ensuring light clothing with no shoes using an electronic scale (Amber Body scale, NUMED SARL, Beirut, Lebanon). The height was measured to the nearest 0.1 kg barefooted using a portable stadiometer (Portable Height scale; NUMED SARL, Beirut, Lebanon). The adolescent's body weight and height were then entered into the 2009 WHO AnthroPlus software and expressed as Z-scores [Height-for-age (HAZ) and BMI-for-age (BAZ)]. Afterward, the adolescent nutrition status was classified as the following: stunting: HAZ ≤ 2 SD; thinness: BAZ ≤ 2 SD; overweight: BAZ > 1 SD; obesity: BAZ > 2 SD (25). As for the parents, the body mass index (BMI) was assessed: values below 18.5 indicates underweight; 18.5–24.9: healthy weight; 25.0–29.9: overweight; 30.0 and Above: Obesity.

For anemia assessment, a portable POC hemoglobin analyzer (CompoLab TS) was used. This is non-invasive anemia detection technology that collect blood through finger pricks method. Following the WHO criteria (26), anemia was diagnosed as the following: boys and girls (younger than 12 years old): Hgb < 11.5 g/dl; boys and girls (12–14 years old): Hgb < 12 g/dl; boys (aged 15 years and older: Hgb < 13 g/dl; girls (aged 15 years and older: Hgb < 12.0 g/dl).

A flow diagram describing the recruitment process is shown in **Figure 1**.

Ethical approval

This study's ethical approval was granted by the Al-Zahraa University Medical Center's ethics committee in Beirut, Lebanon (Reference Nb 12-2022). Informed consent was obtained from all participants, verbally and written. The participants were aware of having the right to deny being part of this study and withdraw for any reason. We adhered to the Helsinki declaration guidelines while conducting this study.

Data analysis

The data was exported to the Statistical Package of Social Sciences Software (SPSS) (Version 25.0. IBM Corp: Armonk, NY, USA) for analysis. Descriptive measures, including frequency (*N*), percentage (%), mean, and standard deviation (SD) were obtained to summarize our findings. The Mann–Whitney *U* test was used to detect mean differences of non-normal data. The chi-squared (χ^2) test was used to determine associations between the study variables. The Fisher's exact test was used when one or more of the cell counts in a 2 × 2 table are less than 5. The

TABLE 2 Adolescents' demographic characteristics and nutrition status, and the self-reported adolescent food security status.

	Overall (*N* = 450)		Girls (*n* = 246)		Boys (*n* = 204)		
	Mean	SD	Mean	SD	Mean	SD	*P*-value
Age (in years)	15.0	3.0	15.0	3.0	14.0	3.0	<0.001**
	N	%	*N*	%	*N*	%	
Adolescence stage							< 0.001**
Early adolescence (10–13 years old)	180	40.0	86	35.0	94	46.1	
Middle adolescence (14–16 years old)	122	27.1	55	22.4	67	32.8	
Late adolescence (17–19 years old)	148	32.9	105	42.6	43	21.1	
Primary caregiver							0.05*
Either parent	17	3.8	11	4.4	6	3	
Both parents	421	93.6	224	91.1	197	96.6	
Others	12	2.7	11	4.5	1	0.5	
Currently working							0.27
No	419	93.1	232	94.3	187	91.7	
Yes	31	6.9	14	5.7	17	8.3	
Education							< 0.001**
School education level	358	79.6	177	72.0	181	88.7	
University education level	92	20.4	69	28.0	23	11.3	
School type							0.09
Public	183	45.1	87	41.0	96	49.5	
Private	223	54.9	125	59.0	98	50.5	
Receiving nutrition education at school							0.80
No	325	90.8	160	90.4	165	91.2	
Yes	33	9.2	17	9.6	16	8.8	
Nutrition status							
Stunting	30	6.7	18	7.3	12	5.9	0.54
Thinness	21	4.7	5	2.0	16	7.8	0.004*
Overweight/obesity	145	32.2	71	28.9	74	36.3	0.09
Anemia	75	16.7	40	16.3	35	17.2	0.79
Adolescents' self-reported food security status							0.59
Food-secure	207	46.0	116	47.2	91	44.6	
Food-insecure	243	54.0	130	52.8	113	55.4	

*Significant at p-value < 0.05 for the χ^2 test; **significant at p-value < 0.001 for the χ^2 test.

binary logistic regression (Backward stepwise LR method) was performed to determine the extent of contribution of parental FL and adolescents' NL in determining the household and adolescents' self-reported food security and adolescents' nutrition status, along with the other factors. A *p*-value of 0.05 and below was considered significant for all analytical tests.

Results

Household food security status, demographic and socioeconomic characteristics of parents

Parents, as well as their adolescent children, were recruited representatively from all Lebanese governorates, predominately from Mount Lebanon (37.3%). Among the 450 sampled parents, 59.0% were females. Almost half of them were aged between 30 and 45 years old, and 49.0% were aged between 46 and 64 years old. Almost 48.4% of the parents had normal body weight, and 49.7% were overweight or obese. The majority of parents were married (95.8%), and 54.0% had 2–3 children. Most of the parents had a school education level (65.0%), and around half (49.3%) reported having no occupation. Around 23.0% of parents reported having no income or < 1.5 million Lebanese Pound (LBP) equivalent to 42$ (for a rate of 35,000 LBP for 1$) as family monthly income, with 21.8% reporting a recent decline in the income. Nearly half (45.0%) of parents were living in crowded homes. In addition, 68.2% of the households were food insecure (Table 1).

Adolescents' demographic characteristics, nutrition status, and self-reported food security status

Among the adolescent sample, 54.6% were girls. Around 40.0% of the adolescents aged 10–13 years old, 27.1% were aged between 14 and 16 years old, and 32.9% were 17–19 years old. More girls (42.6%) than boys (21.1%) were in the late adolescence stage, $p < 0.001$. Almost all (93.6%) were living with both parents. A few (6.9%) of the adolescents were working. Most of the adolescents (79.6%) were school students (45.1% of them were at public schools), while the remaining (20.4%) had a university education level. Almost all the adolescents (91.0%) were not receiving nutrition education in the schools' curriculum. Additionally, 6.7% of adolescents were stunted, 4.7% were wasted, 32.2% were overweight or obese, and 16.7% had anemia.

TABLE 3 The status of adolescents' NL and parenteral FL.

Adolescents	Overall (*N* = 450)	Gender		*P*-value
		Girls (*n* = 246)	Boys (*n* = 204)	
	N (%)	*n* (%)	*n* (%)	
TNL[(1)]				
Poor	201 (44.7)	94 (38.2)	107 (52.5)	0.002*
Adequate	249 (55.3)	152 (61.8)	97 (47.5)	
FNL[(2)]				
Poor	207 (46.0)	100 (40.7)	107 (52.5)	0.012*
Adequate	243 (54.0)	146 (59.3)	97 (47.5)	
INL[(3)]				
Poor	222 (49.3)	111 (45.1)	111 (54.4)	0.05*
Adequate	228 (50.7)	135 (54.9)	93 (45.6)	
CNL[(4)]				
Poor	173 (38.4)	89 (36.2)	84 (41.2)	
Adequate	277 (61.6)	157 (63.8)	120 (58.8)	
Parents	Overall (*N* = 450)	Females (*n* = 266)	Males (*n* = 184)	*p*-value
FL[(5)]	*N* (%)	*n* (%)	*n* (%)	0.63
Poor	215 (47.8)	115 (46.7)	100 (49.0)	
Adequate	235 (52.2)	131 (53.3)	104 (51.0)	

[(1)]TNL, total nutrition literacy; [(2)]FNL, functional nutrition litarcy; [(3)]INL, interactive nutrition literacy; [(4)]CNL, critical nutition literacy; [(5)]FL, food literacy; *significant at *p*-value < 0.05.

TABLE 4 The contribution of the adolescents' NL and parental FL to predicting the household and adolescents' self-reported FI and adolescents' nutrition status.

Model 1: The dependent variable is the household food security (food-secure (reference) vs. food-insecure)	OR (95 % CI)	*P*-value
Parental FL (Reference: Adequate)		
Poor	2.7 (1.8–4.3)	<0.001**
Number of children (Reference: One child)	1.0	–
More than one child	6.7 (3.0–14.9)	<0.001**
Monthly income of the family (Reference: > 1.5 million LBP)		
None or less than 1.5 million LBP	2.4 (1.4–4.3)	0.004*
Model 2: The dependent variable is the adolescents' self-reported food security (food-secure (reference) vs. food-insecure)		
Adolescent's NL (Reference: Adequate)	1.0	–
Poor	1.6 (1.1–2.3)	0.02*
Residence (Reference: Other governorates)		
Akkar	4.5 (1.8–11.1)	0.001*
Household crowding (Reference: No)		
Yes	1.4 (1.0–2.2)	0.04*

OR, odds ratio; CI, confidence interval; *significant at p-value < 0.05; **significant at p-value of <0.001.

Furthemore, 54.0% of the adolescents were food insecure (Table 2).

Adolescents' NL and Parents's FL

Overall, around 45.0% of adolescents were nutritionally illiterate. In particular, 46.0% had poor FNL, 49.3% had poor INL, and 38.4% had poor CNL. More boys (52.5%) than girls were nutritionally illiterate (38.2%), p = 0.002. Boys' FNL and INL were significantly worse than that of girls (52.5% of boys vs. 40.7% of girls had poor FNL; 54.4% of boys vs. 45.1% of girls had poor INL), p = 0.01. Almost 47.8% of the parents were food illiterate, particularly fathers (49.0% vs. mothers: 51.0%, p = 0.005; Table 3).

Impact of adolescents' NL and parental FL on the household's and adolescents' food security, the adolescents' nutrition status with focus on malnutrition and anemia. Supplementary Table 1 shows that households residing in Baalbeck-Hermel had the highest percentage of FI (82.2%), p < 0.001. Besides, households composed of more than 3 children were the most food-insecure (76.9%), p < 0.001. FI predominated among households with uneducated parents (88.6%), p = 0.005 andwas most prevalent in households earning less than 1.5 million LBP (78.4%), p = 0.01. Crowded households had a higher percentage of FI (73.3%) than non-crowded ones (64.1%), p = 0.04. Around 78.1% of food illiterate parents were belonging to food-insecure households, p < 0.001 (Supplementary Table 1).

Adolescents residing in Akkar were most food-insecure (84.6%), p < 0.001. Adolescents experienced more FI if they were belonging to households earning less than 1.5 million LBP (62.7%) monthly income, p = 0.04. Besides, 60% of adolescents living in crowded households were food-insecure, p = 0.01. More than half of nutritionally illiterate adolescents (60.7%) were observed to have FI, p = 0.01.

As for stunting, thinness, overweight/obesity, and anemia, these were not influenced by adolescents' NL or parental FL; however, they were associated with other study variables. For instance, adolescents studying at school were more stunted (8.1%) than those who were university students (1.1%), p = 0.02. Thinness was more prevalent among boys (7.8%) than girls (2.0%), p = 0.004. Households reporting a recent decline in their salary had the highest proportion of thin adolescent children (9.2%), p = 0.02. Additionally, 40.0% of overweight or obese parents had an overweight/obese adolescent child, p = 0.002. Lower parental education level (school vs. university level) was associated with a higher percentage of adolescent with overweight/obesity (36.6% vs. 26.8%), p = 0.009. Anemia was mostly prevalent among adolescents residing in Akkar (36.0), p = 0.01 (Supplementary Table 1).

Bivariate analysis on the impact of NFL on parents-adolescents dyads' nutrition status and food security

Depending on the bivariate analysis shown above, we determined the contribution of the adolescents' NL and parental FL to predicting the household and adolescents' self-reported FI. Table 4 shows that the percentage of household FI increased 2.7 times when parents had poor FL (OR = 2.7, CI = 1.8–4.3 p < 0.001). As well, the number of children and family income predicted the risk of household FI. FI was around 7 times higher among households having more than one child (vs. one child; OR = 6.7, CI = 3.0–14.9, p < 0.001). Besides, households having no or less than 1.5 million LBP monthly income were 2.4 times more likely to be food-insecure (OR = 2.4, CI = 1.4–4.3, p = 0.004) (Model 1; Table 4).

Nutritionally illiterate adolescents were 60% more likely to self-experience FI (OR = 1.6, CI = 1.1–2.3, p = 0.02). In addition, adolescents residing in Akkar (OR = 4.5, CI = 1.8–11.1, p < 0.001), and in crowded households (OR = 1.6, CI = 1.1–2.3, p = 0.02) were 4.5 and 1.4 times more probable to be food-insecure, respectively (Model 2; Table 4).

Discussion

This is the first study of its kind in Lebanon and the Arab region that investigated the impact of NFL among parent's-adolescents dyads on household's food insecurity, malnutrition and anemia.

In the MENA region, the studies addressing NL and FL status are scant so far. This is evident in a recent review (27) on the FL and NL status, which warns regional researchers to start taking incremental steps to address these concepts in the MENA region. In Lebanon, only one preliminary study was conducted to assess the NL of adolescents and observed a lower percentage of poor NL (21.2%) than that currently reported (28). Moreover, our findings with regards to adolescents' NL is similar to that reported among Chinese (27), and Turkish adolescents (29, 30). Our findings are warrantable and could be partially explained by the fact that almost all (91.0%) of the adolescents reported not receiving nutrition education in their schools' curriculum in the current study. Schools are ideal systems that provide a unique platform to enhance nutrition awareness by providing a variety of interventions and extracurricular activities (31). In this regard, the school-based program Teens Eating for Energy and Nutrition at School (TEENS) was a success in encouraging adolescents to choose lower-fat food selections from the cafeteria (32). Besides, a nutrition education intervention, delivered for 3 months in schools, improved adolescents' knowledge, attitude, and behaviors related to breakfast in Indonesia (33). These results are therefore encouraging to be taken into consideration at the Lebanese schools, which of course calls for a multisector discussion between the Ministry of Education and Higher Education (MEHE), the Ministry of Public Health (MOPH), and, of course, the recently established Lebanese Order of Dietitians. School-based interventions to improve NL are many and include classroom activities, farm-to-school programs, and school garden programs (31). The advantage of nutrition education might be extended to include other children at home as well as the guardians through morning text messages with nutrition-related material, assigning cooking tasks, and group interviews with parents (31). The present findings also reveal that boys were more nutritionally illiterate than girls, $p = 0.002$. Girls are usually concerned about the energy and nutrition content of the food they eat due to body image concerns and body weight idealism objectives, particularly in adolescence (28). Furthermore, nearly half of the parents were food-illiterate in the current study. This finding is supportive of previous research emphasizing the need to develop parental FL programs to promote healthy eating habits for their families (34). In Greece, higher parental levels of FL predicted adequate feeding practices for their children (35). To attain nutrition goals, it is therefore insufficient to merely target adolescents through school-based or other initiatives; instead, it is essential to include parents in large-scale efforts.

As outlined in our findings, poor NL among adolescents and inadequate FL among their parents could lead adolescents to have an additional burden of malnutrition prevalence. Stunting, wasting, overweight, obesity, and anemia were all considerably prevalent among our adolescent sample and comparable to other studies (35–37). This is, of course, a finding to be worried about, since Lebanese adolescents are anticipated to face additional risks of malnutrition, due to the ongoing conflicts they are already dealing with. As a result, a lack of NL will cause the problem to escalate to terrifying levels.

FL and NL programs relieve FI in poor and wealthy communities

In the current study, poor parental FL and adolescent NL had predicted worse food security status of the sampled households and the adolescents, respectively. These findings supported research from Australia (10) and Iran (13). Similarly, lower cooking self-efficacy and food preparation skills were observed among food-insecure college students (37–39). Today, policymakers and nutrition researchers embrace FL programs as a tool to minimize FI because they emphasize the utilization pillar of food security (10). Nonetheless, the relationship between FL and FI is dual (10). What if I possess adequate FL; however, the food is unavailable or ridiculously expensive? FI might still exist. Likewise, FL is not an exemplar that will eradicate FI under all circumstances. Many immutable factors contribute to causing FI, including the monthly income of the family, limited access to food due to high prices or poor infrastructure, residency, and education (10). These are evidenced in the current study, as the monthly income of the family and the number of children the parent had determined the risk of household FI, along with the parental FL status. In addition, adolescents' residence and the crowding status of the households determined the risk of adolescents' self-experienced FI. Ultimately, FL is one of the countless risk factors that shape FI in a population. However, it is crucial to focus on it because it is highly malleable and amenable to interventions.

Food and nutrition literacy interventions could help build resilience against FI in lebanon

FI affects more than half the Lebanese population, according to much evidence (14–16, 40–42). The current study showed worse food security status in Lebanon among parents-adolescents dyads. Joblessness, stagnating income, declining purchasing power due to insane inflation, and a lack of social safety nets have had a significant negative impact on livelihoods (43). There is little chance of escaping or finding relief from the current economic crisis in Lebanon, thanks to the poor governance and the "no" actions taken to strengthen the

national food system. Thus, FL and NL interventions could help in building resilience against FI in Lebanon. Schools, without a doubt, could be the perfect place to get in touch with adolescents and their parents and begin interfering with their food and nutrition literacy levels.

Study limitations and strengths

There are some study limitations that the authors have to acknowledge. This is a cross-sectional study; therefore, associations between study variables could be driven with no causality. Due to the unavailability of valid nutrition and food literacy questionnaires in Lebanon, we used the Arabic translated questionnaires from Swiss and Turkish studies. However, this study is the first of its kind enrolling a representative sample of parent-adolescent dyads with the aforementioned objectives.

Conclusion and implications

A significant proportion of Lebanese adolescents were nutrition illiterate, and nearly half of their parents had poor FL levels. Inadequate levels of adolescents' NL and parental FL worsened adolescents' and households' food security status, respectively. Today, amid the national overwhelming crises, FL and NL interventions should be considered in Lebanon, preferably in school settings, to mitigate the devastating effects of FI and malnutrition. Investments in education sectors are promising to lead to durable, sustainable and effective nutrition outcomes; however, this calls for agility, resiliency, and tenacity from all stakeholders.

Data availability statement

The original contributions presented in this study are included in the article/**Supplementary material**, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Al Zahraa University Medical Center Beirut Lebanon. Written informed consent to participate in this study was provided by the participants or their legal guardian/next of kin.

Author contributions

MH and HM contributed to the conceptualization, data curation, formal analysis, investigation, methodology, project administration, and writing—original draft preparation. YS and LH-W contributed to the writing—review and editing. MH was responsible for supervision and validation. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnut.2022.1053552/full#supplementary-material

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Associations between negative gender attitudes and eating behaviors in Chinese children and adolescents

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Background: Negative gender cognitive attitudes (disliking one's own gender or wanting to be the opposite gender) and unhealthy eating behaviors have become common in Chinese children and adolescents. The aim of this study was to analyze the associations between negative gender attitudes and eating behaviors among Chinese children and adolescents.

Methods: Primary and secondary school students aged 8–15 years were selected as participants using a stratified cluster random sampling method. The self-designed questionnaire was used to investigate the participants' negative gender cognitive attitudes. Eating frequency questionnaire was used to investigate participants' eating behaviors. Under the leading reading of standardized training investigators, the questionnaire for children aged 8–15 years was completed by themselves in the form of centralized filling.

Results: A total of 6.5% [43/657, boys: 6.1% (21/347), girls: 7.1% (22/310)] of children disliked their own gender, 8.8% [58/657, boys: 5.5% (19/347), girls: 12.6% (39/310)] of children wanted to be of the opposite gender, and the proportion of girls with negative gender attitudes was higher than that of boys ($P < 0.05$). Boys who disliked their own gender or wanted to be the opposite gender had higher frequencies of unhealthy eating behaviors and lower frequencies of healthy eating behaviors than boys who liked their own gender or did not want to be the opposite gender ($P < 0.05$). Girls who disliked their own gender or wanted to be the opposite gender had higher frequencies of protein eating behaviors than girls who liked their own gender or did not want to be the opposite gender ($P < 0.05$). There was a significant interaction between disliking one's own gender and wanting to be the opposite gender in midnight snack eating among boys ($P < 0.05$) and in carbonated drink and high protein eating behaviors among girls ($P < 0.05$).

Conclusion: Boys with negative gender cognitive attitudes express more unhealthy eating behaviors and fewer healthy eating behaviors; girls with negative gender cognitive attitudes exhibit more protein eating behaviors.

KEYWORDS

disliking your own gender, wanting to be opposite gender, eating behaviors, children and adolescents, negative gender attitudes

Introduction

The gender role is the construction of gender attitudes, behaviors, cognitions and emotions in a specific cultural background (1). Most children's gender experience of being male or female is in line with the gender assigned at birth, but inconsistencies can lead to gender dysphoria (2). Children who have a strong desire to be another gender are defined as children with gender dysphoria (3, 4). A study among Dutch children showed that 1.4% of boys wished to be of the opposite gender, and 2.0% of girls wished to be of the opposite gender (5). Recent studies suggested that the prevalence of a self-reported transgender identity in children and adolescents ranges from 0.5 to 1.3% and is more prominent among girls than boys (6). Compared with children without gender dysphoria, children with gender dysphoria have a higher risk of eating disorders (7, 8). Some studies in Canadian adolescents showed that 5% of adolescents with gender dysphoria had eating disorders (9). Transgender adolescents participate in negative eating behaviors to change their appearance or modify their bodies to adapt to their gender identity (10). The increase in disordered eating behaviors will lead to higher dissatisfaction with their bodies (11) and contribute to adolescents becoming sexual minorities. Gender role orientation plays an important role in adolescent eating disorders (12). Some children and adolescents may not be defined as gender dysphoric, but they may dislike their gender or want to be the opposite gender. There have been few reports on whether these negative gender attitudes are related to eating behaviors.

Adolescence is a window of opportunity to develop healthy dietary patterns and nutritional status, which may have lasting effects on future health (13). The unhealthy dietary characteristics of adolescents include a low intake of fruits and vegetables and a high intake of energy-intensive and nutrient-poor foods, such as carbonated drinks and western fast food (14). Micronutrient deficiencies are prevalent among adolescents, with profound effects on their quality of life, risk of premature death, and the health of their offspring (15). Dietary quality plays a key role in preventing these forms of adolescent malnutrition. High intake of fruits and vegetables has been associated with increased blood vitamin concentrations in European adolescents (16), while low intake is a major contributor to the global burden of disease, particularly non-communicable diseases (17). Carbonated drinks usually contain a small amount of nutrients and sugar. Drinking sugary drinks is closely related to obesity and type 2 diabetes in adolescents (18). Adolescents' fast food consumption is associated with metabolic markers of obesity, diabetes and cardiovascular disease (19).

Healthy eating behaviors are important to develop health among children, and negative gender attitudes may play an important role in eating behaviors. The purpose of this study was to analyze the associations between negative gender attitudes and eating behaviors, which is a new perspective to promote healthy eating behaviors among children and adolescents.

Materials and methods

Participants

A total of 692 students (369 boys and 318 girls) aged 8–15 years were selected from two 9-year compulsory education schools using the stratified cluster sampling method. There were 657 effective samples (347 boys, 310 girls), and the effective rate was 99.0%. The project was approved by the Medical Research Ethics Committee of Bengbu Medical College [(2015) No. 003], and participants' guardians signed informed consent forms. This study was conducted in accordance with the Declaration of Helsinki.

Measurement

Medical staff who receive standardized training were recruited as surveyors. The participants were asked to have an empty stomach, wear light clothes, and be barefoot. Height was measured using a mechanical height meter to the nearest 0.1 cm. Weight was measured using an electronic body weight meter to the nearest 0.1 kg. Waist circumference (WC) was measured to the nearest 0.1 cm using a nylon tape scale. WC is the circumference of the waist along a horizontal line at 1 cm above the navel. BMI = Weight (kg)/Height $(m)^2$; Waist-to-height ratio (WHtR) = WC (cm)/Height (cm). The students were divided into overall

TABLE 1 Exploratory factor analysis of eating behavior frequency.

Eating behaviors	Load of unhealthy eating behavior factor	Load of healthy eating behavior factor	Load of protein eating behavior factor
Dine out	0.567		
Midnight snack	0.489		
Fried food	0.671		
High-calorie snacks	0.696		
Preserved vegetables	0.395		
Western fast food	0.631		
Carbonated drink	0.578		
Fish meat			0.849
Shrimps			0.827
Eggs		0.636	
Milk		0.704	
Fresh vegetables		0.709	
Fruits		0.751	
Breakfast		0.492	
Eigenvalue	2.453	2.279	1.638
Contribution rate (%)	17.519	16.282	11.700
Cumulative contribution rate (%)	17.519	33.801	45.501

overweight/obese and non-overweight/obese groups according to the sex-age BMI standard (20). According to the standard of WHtR $\geq$ 0.46, children and adolescents were divided into abdominal obesity and non-abdominal obesity groups (21). Under the leading reading of standardized training investigators, the questionnaires of eating behaviors and negative gender attitude for children aged 8–15 years were completed by themselves in the form of centralized filling.

Eating behaviors survey

An eating frequency questionnaire was used to investigate the frequencies of dining out, midnight snacks, fried food, high-calorie snacks, preserved vegetables, western fast food, carbonated drink, fish meat, shrimps, eggs, milk, fresh vegetables, fruits, and breakfast. The frequency of each eating behavior was assigned as 1 time/day = 7, 4–6 times/week = 5, 1–3 times/week = 2, 1 time/2 weeks = 0.5, 1 time/month = 0.25, and never = 0 (22). The higher the score, the higher the frequency of eating behaviors. The Cronbach coefficient of the questionnaire was 0.630. Exploratory factor analysis (EFA) was used to extract 3 common factors from 14 eating behaviors by orthogonal rotation with maximum variance, including unhealthy eating behavior, healthy eating behavior and protein eating behavior. The unhealthy eating behavior factor included dining out and consuming midnight snacks, fried food, high-calorie snacks, preserved vegetables, western fast food, and carbonated drink; the healthy eating behavior factor included eggs, milk, fresh vegetables, fruits and breakfast; and the protein eating behavior factor included fish, meat and shrimp. The KMO test value of factor analysis was 0.770, and Bartlett's sphericity test showed a statistically significant difference ($\chi^2 = 1465.198$, $P < 0.001$) (see Table 1 for details).

Negative gender attitude survey

The self-designed questionnaire was developed to investigate children and adolescents' negative gender attitudes.

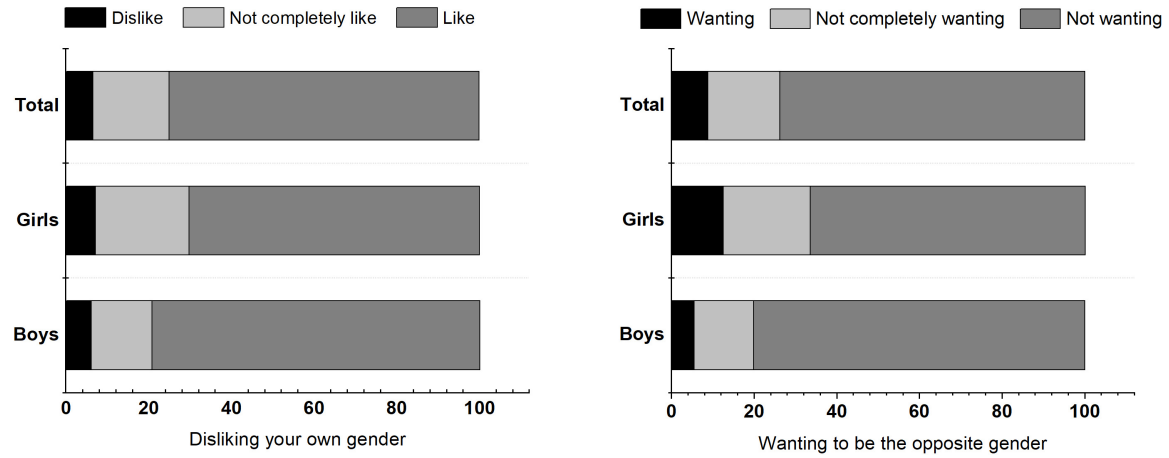

FIGURE 1
Proportion of disliking your own gender and wanting to be the opposite gender among children and adolescents.

TABLE 2 Comparisons of differences in age, eating behaviors, gender attitude, and body shape between boys and girls.

Variables	Boys (n = 347)	Girls (n = 310)	t/X^2	P
Age	11.3 ± 1.8	11.5 ± 1.80	0.17	0.677
Dine out	2.2 ± 2.3	1.8 ± 2.1	3.64	0.057
Breakfast	6.1 ± 1.8	5.8 ± 2.1	8.92	0.003
Fried food	2.0 ± 2.1	1.9 ± 2.1	0.10	0.755
High-calorie snacks	2.0 ± 2.3	2.0 ± 2.2	0.55	0.461
Midnight snack	1.9 ± 2.6	1.4 ± 2.5	8.22	0.004
Western fast food	1.0 ± 1.8	0.8 ± 1.5	10.82	0.001
Carbonated drink	1.4 ± 2.0	0.8 ± 1.5	37.33	0.001
Preserved vegetables	2.0 ± 2.3	1.6 ± 2.1	4.97	0.026
Fish meat	2.7 ± 2.3	2.1 ± 2.2	9.61	0.002
Shrimps	1.7 ± 2.2	1.5 ± 1.9	5.88	0.016
Eggs	4.8 ± 2.5	4.6 ± 2.6	4.42	0.036
Fresh vegetables	5.3 ± 2.3	5.5 ± 2.2	0.43	0.512
Fruits	5.6 ± 2.0	5.5 ± 2.2	1.74	0.188
Unhealthy eating behavior factor	0.1 ± 1.05	−0.11 ± 0.93	4.22	0.040
Healthy eating behavior factor	0.04 ± 1.00	−0.05 ± 1.00	0.15	0.694
Protein eating behavior factor	0.11 ± 1.05	−0.12 ± 0.93	5.94	0.015
disliking your own gender			6.97	0.008
Yes	72 (20.7)	92 (29.7)		
No	275 (79.3)	218 (70.3)		
Wanting to be the opposite gender			15.76	0.000
Yes	69 (19.9)	104 (33.5)		
No	278 (80.1)	206 (66.5)		
Overall overweight or obesity			2.65	0.104
Yes	119 (34.3)	88 (28.4)		
No	228 (65.7)	222 (71.6)		
Abdominal obesity			3.85	0.050
Yes	115 (33.1)	81 (26.1)		
No	232 (66.9)	229 (73.9)		

Question 1 (Disliking your own gender): Do you like your own gender? Answer: Like, Not completely like, Dislike. Disliking your own gender was divided into two ranks: "Yes" ("Not completely like" or "dislike") and "No" ("Like"). Question 2 (Wanting to be the opposite gender): Do you want to be a member of the opposite gender? Answer: Not wanting, Not completely wanting, Wanting (23). Wanting to be the opposite gender was divided into two ranks: "Yes" ("Wanting" or "Not completely wanting") and "No" ("Not wanting"). The Cronbach's coefficient of the questionnaire was 0.728.

Statistical analyses

All analyses were conducted using IBM SPSS 23.0 software. The quantitative data are described as the mean ± SD, and count data are described as the rate or proportion (%). Two independent sample t-tests were used to compare the differences in quantitative variables between the two groups. The *chi*-square test was used to compare the differences in qualitative variables between the two groups. After adjusting for age and body type, multiple linear regression was used to analyze the relationships between negative gender attitudes and eating behaviors. $P < 0.05$ was considered statistically significant.

Results

Differences in age, eating behaviors, gender attitudes, and body shape between boys and girls

A total of 657 adolescents aged 8–15 years were included in this study, including 347 boys and 310 girls. The proportion of children disliking their own gender was 6.5% [43/657, boys: 6.1% (21/347), girls: 7.1% (22/310)], and the proportion of children who wanted to be of the opposite gender was 8.8% [58/657, boys: 5.5% (19/347), girls: 12.6% (39/310)] (see **Figure 1** for details). The proportion of girls with the above negative gender attitudes was significantly higher than those of boys ($P < 0.05$). The proportion of children with abdominal obesity and overall overweight or obesity was 29.8% [196/657, boys: 33.1% (115/347), girls: 26.1% (81/310)] and 31.5% [207/657, boys: 34.3% (119/347), girls: 28.4% (88/310)], respectively, and was higher in boys than in girls ($P < 0.05$). There was no significant difference in age between boys and girls ($P > 0.05$). The frequencies of consuming breakfast, midnight snacks, preserved vegetables, western fast food, carbonated drinks, fish, meat, and shrimp were higher in boys than in girls, as well as unhealthy eating behaviors and high protein eating behaviors ($P < 0.05$). There were no significant differences between boys and girls in the frequencies of dining out, eating fried food, high-calorie snacks, fresh vegetables and fruits ($P > 0.05$) (see **Table 2** for details).

TABLE 3 Comparisons of differences in eating behaviors, negative gender attitude between children and adolescents with different body shapes.

Variables	Overall overweight or obesity		t/X^2	*P*	Abdominal obesity		t/X^2	*P*
	Yes (*n* = 207)	No (*n* = 450)			Yes (*n* = 196)	No (*n* = 461)		
Boys								
Dine out	2.5 ± 2.3	2.1 ± 2.3	0.60	0.441	2.7 ± 2.4	2.0 ± 2.2	5.31	0.022
Breakfast	6.0 ± 1.8	6.2 ± 1.7	2.53	0.113	6.0 ± 1.9	6.2 ± 1.7	3.68	0.056
Midnight snack	1.7 ± 2.5	1.9 ± 2.7	0.34	0.559	1.8 ± 2.6	1.9 ± 2.6	0.15	0.701
Fried food	2.2 ± 2.2	1.9 ± 2.1	0.30	0.583	2.1 ± 2.1	1.9 ± 2.1	0.07	0.800
High-calorie snacks	1.9 ± 2.2	2.1 ± 2.3	0.05	0.817	1.9 ± 2.3	2.1 ± 2.3	0.01	0.920
Western fast food	1.1 ± 1.9	1.0 ± 1.7	0.75	0.388	1.2 ± 2.0	0.9 ± 1.7	5.64	0.018
Carbonated drink	1.5 ± 2.0	1.4 ± 2.0	0.05	0.822	1.6 ± 2.2	1.4 ± 1.9	2.82	0.094
Preserved vegetables	2.1 ± 2.3	2.0 ± 2.3	0.45	0.501	2.1 ± 2.3	2.0 ± 2.3	0.21	0.650
Fish meat	2.6 ± 2.4	2.7 ± 2.2	0.76	0.384	2.7 ± 2.4	2.7 ± 2.2	1.45	0.229
Shrimps	1.9 ± 2.3	1.7 ± 2.2	0.03	0.870	2.0 ± 2.4	1.6 ± 2.1	2.59	0.109
Eggs	4.6 ± 2.4	4.9 ± 2.5	0.76	0.384	4.7 ± 2.4	4.8 ± 2.5	0.706	0.401
Milk	5.5 ± 2.1	5.5 ± 2.2	0.10	0.758	5.4 ± 2.2	5.6 ± 2.1	0.14	0.709
Fresh vegetables	5.1 ± 2.3	5.4 ± 2.3	0.01	0.926	5.1 ± 2.3	5.4 ± 2.2	0.07	0.799
Fruits	5.6 ± 1.9	5.6 ± 2.1	0.74	0.389	5.6 ± 2.0	5.7 ± 2.1	0.37	0.546
Unhealthy eating behavior factor	0.14 ± 0.99	0.07 ± 1.08	0.98	0.324	0.18 ± 1.05	0.05 ± 1.05	0.00	0.996
Healthy eating behavior factor	−0.04 ± 0.98	0.08 ± 1.01	0.17	0.678	−0.05 ± 1.03	0.09 ± 0.98	0.10	0.759
Protein eating behavior factor	0.13 ± 1.12	0.09 ± 1.01	1.78	0.183	0.19 ± 1.15	0.07 ± 0.99	5.60	0.019
Disliking your own gender			1.44	0.230			2.09	0.148
Yes	29 (24.4)	43 (18.9)			29 (25.2)	43 (18.5)		
No	90 (75.6)	185 (81.1)			86 (74.8)	189 (81.5)		
Wanting to be the opposite gender			0.01	0.924			0.11	0.746
Yes	24 (20.2)	45 (19.7)			24 (20.9)	45 (19.4)		
No	95 (79.8)	183 (80.3)			91 (79.1)	187 (80.6)		
Girls								
Dine out	1.7 ± 2.2	1.8 ± 2.1	0.11	0.746	1.7 ± 2.1	1.8 ± 2.2	0.002	0.965
Breakfast	5.7 ± 2.2	5.9 ± 2.0	1.10	0.295	5.5 ± 2.2	5.9 ± 2.0	2.50	0.115
Midnight snack	0.9 ± 2.1	1.6 ± 2.6	13.47	0.000	1.1 ± 2.3	1.5 ± 2.5	3.14	0.077
Fried food	1.4 ± 1.8	2.0 ± 2.2	2.43	0.120	1.6 ± 1.9	2.0 ± 2.2	1.84	0.176
High-calorie snacks	2.1 ± 2.3	2.0 ± 2.1	0.84	0.361	1.9 ± 2.2	2.1 ± 2.2	0.27	0.604
Western fast food	0.7 ± 1.3	0.8 ± 1.6	0.54	0.462	0.7 ± 1.2	0.8 ± 1.6	1.55	0.214
Carbonated drink	1.0 ± 1.8	0.8 ± 1.4	7.00	0.009	1.1 ± 1.8	0.7 ± 1.4	7.93	0.005
Preserved vegetables	1.5 ± 2.1	1.6 ± 2.1	0.32	0.573	1.5 ± 2.0	1.6 ± 2.1	0.70	0.402
Fish meat	2.1 ± 2.2	2.1 ± 2.2	0.21	0.645	2.0 ± 1.9	2.2 ± 2.3	6.31	0.013
Shrimps	1.7 ± 2.0	1.4 ± 1.9	0.40	0.530	1.7 ± 1.8	1.4 ± 2.0	0.68	0.411
Eggs	4.0 ± 2.7	4.9 ± 2.6	5.40	0.021	4.0 ± 2.8	4.8 ± 2.5	12.53	0.000
Milk	5.3 ± 2.4	5.3 ± 2.2	0.75	0.388	5.5 ± 2.2	5.3 ± 2.3	2.44	0.119
Fresh vegetables	5.4 ± 2.3	5.5 ± 2.1	1.79	0.182	5.7 ± 2.1	5.4 ± 2.2	0.39	0.535
Fruits	5.3 ± 2.2	5.5 ± 2.1	0.82	0.367	5.2 ± 2.2	5.6 ± 2.1	0.63	0.430

(Continued)

TABLE 3 (Continued)

Variables	Overall overweight or obesity		t/X^2	P	Abdominal obesity		t/X^2	P
	Yes (n = 207)	No (n = 450)			Yes (n = 196)	No (n = 461)		
Unhealthy eating behavior factor	−0.23 ± 0.94	−0.06 ± 0.92	0.22	0.639	−0.19 ± 0.92	−0.08 ± 0.94	0.002	0.967
Healthy eating behavior factor	−0.19 ± 1.04	0.01 ± 0.99	0.14	0.706	−0.16 ± 1.03	−0.01 ± 0.99	0.12	0.732
Protein eating behavior factor	0.00 ± 0,96	−0.16 ± 0.91	0.32	0.574	−0.07 ± 0.81	−0.14 ± 0.97	2.63	0.106
Disliking your own gender			0.06	0.807			0.31	0.579
Yes	27 (30.7)	65 (29.3)			26 (32.1)	66 (28.8)		
No	61 (69.3)	157 (70.7)			55 (67.9)	163 (71.2)		
Wanting to be the opposite gender			0.45	0.501			0.35	0.552
Yes	27 (30.7)	77 (34.7)			25 (30.9)	79 (34.5)		
No	61 (69.3)	145 (65.3)			56 (69.1)	150 (65.5)		

Comparisons of eating behaviors and negative gender attitudes between children and adolescents with different body shapes

The frequency of drinking carbonated drinks among girls with overall overweight or obesity was higher than that of girls with non-overall overweight or obesity, but the frequencies of eating midnight snacks and eggs among girls with non-overall overweight or obesity were higher than those of girls with overall overweight or obesity. The frequencies of dining out, eating western fast food and high protein eating behaviors among abdominally obese boys were higher than those in non-abdominally obese boys ($P < 0.05$). The frequency of drinking carbonated drinks among girls with abdominal obesity was higher than that in girls with non-abdominal obesity ($P < 0.05$), but the frequencies of eating fish, meat and eggs among girls with non-abdominal obesity were higher than those in girls with abdominal obesity ($P < 0.05$) (see **Table 3** for details).

Comparisons of eating behaviors of children and adolescents who dislike their own gender and who like their own gender

The results showed that boys who disliked their own gender had higher frequencies of dining out and eating midnight snacks, high-calorie snacks, western fast food, preserved vegetables, unhealthy eating behaviors and protein eating behaviors than boys who liked their own gender. Girls who liked their own gender ($P < 0.05$) consumed fruits and fresh vegetables less frequently and expressed fewer healthy eating behaviors than both boys who liked their own gender and girls who liked their own gender (except for fruits) ($P < 0.05$). Girls who disliked their own gender dined out and consumed western fast food, carbonated drinks, fish, meat, and shrimp more frequently and exhibited more protein eating behaviors than girls who liked their own gender ($P < 0.05$). However, there were no significant differences in dining out or consuming western fast food, carbonated drinks, fish, meat, shrimp and protein eating behaviors between girls who disliked their own gender and boys who liked their own gender (see **Table 4** for details).

Comparisons of eating behaviors of children and adolescents who want to be the opposite gender and those who do not

The results showed that boys who wanted to be the opposite gender ate western fast food, high-calorie snacks, and preserved vegetables more frequently and exhibited more unhealthy eating behaviors than boys who did not want to be the opposite gender. Girls who did not want to be the opposite gender ($P < 0.05$) ate eggs, fresh vegetables, and fruits less frequently and exhibited fewer healthy eating behaviors than boys who did not want to be the opposite gender ($P < 0.05$) and ate fresh vegetables and fruits less frequently than girls who did not want to be the opposite gender ($P < 0.05$). There were no significant differences in the frequencies of eating eggs and healthy eating behaviors between boys who wanted to be of the opposite gender and girls who did not want to be of the opposite gender ($P > 0.05$). Girls who wanted to be the opposite gender ate shrimp, fish, and meat more frequently and expressed more high protein eating behaviors than girls who did not want to be the opposite gender ($P < 0.05$) and ate eggs less frequently than girls who did not want to be the opposite gender and boys who did not want to be the opposite gender ($P < 0.05$). There were no significant differences in the frequencies of shrimp, fish, and meat consumption or high protein eating behaviors between

TABLE 4 Comparisons of differences in eating behaviors between children and adolescents with disliking their own gender and liking their own gender.

Variables	Disliking your own gender in boys		t/X^2	*P*	Disliking your own gender in girls		t/X^2	*P*
	Yes (*n* = 72)	No (*n* = 275)			Yes (*n* = 92)	No (*n* = 218)		
Dine out	2.8 ± 2.5[a]	2.1 ± 2.2	0.25	0.013	2.1 ± 2.4	1.7 ± 2.0[a]	4.49	0.035
Breakfast	6.0 ± 2.0	6.2 ± 1.7	2.92	0.089	5.8 ± 2.0	5.8 ± 2.1	0.00	0.992
Midnight snack	2.6 ± 2.9[a]	1.7 ± 2.5	9.22	0.003	1.3 ± 2.5	1.4 ± 2.5[a]	0.13	0.720
Fried food	2.3 ± 2.3	1.9 ± 2.1	0.50	0.480	2.1 ± 2.2	1.8 ± 2.1	0.61	0.435
High-calorie snacks	2.4 ± 2.6[a]	1.9 ± 2.2	8.19	0.004	2.3 ± 2.2	1.9 ± 2.1[a]	0.13	0.722
Western fast food	1.5 ± 2.3[a]	0.9 ± 1.6	22.76	< 0.001	1.0 ± 1.9	0.7 ± 1.3[a]	13.96	< 0.001
Carbonated drink	1.7 ± 2.1	1.4 ± 2.0	0.35	0.553	1.1 ± 1.8	0.7 ± 1.4	9.17	0.003
Preserved vegetables	2.6 ± 2.6[a]	1.9 ± 2.2	11.01	0.001	1.8 ± 2.3	1.4 ± 2.0[a]	2.11	0.148
Fish meat	2.7 ± 2.5	2.7 ± 2.3	0.71	0.399	2.5 ± 2.5	2.0 ± 2.0	13.50	< 0.001
Shrimps	1.9 ± 2.4	1.7 ± 2.2	0.52	0.470	1.8 ± 2.3	1.4 ± 1.7	9.63	0.002
Eggs	4.5 ± 2.6	4.9 ± 2.5	0.98	0.324	4.4 ± 2.7	4.7 ± 2.6	0.52	0.470
Milk	5.2 ± 2.4	5.6 ± 2.1	2.94	0.087	5.1 ± 2.3	5.4 ± 2.3	0.04	0.851
Fresh vegetables	4.5 ± 2.7[a]	5.5 ± 2.1	18.55	< 0.001	5.4 ± 2.3	5.5 ± 2.1[a]	0.89	0.346
Fruits	5.3 ± 2.4	5.7 ± 1.9	10.21	0.002	5.4 ± 2.3	5.5 ± 2.1	0.41	0.522
Unhealthy eating behavior factor	0.43 ± 1.29[a]	0.01 ± 0.96	8.12	0.005	0.05 ± 1.01	−0.17 ± 0.89[a]	0.17	0.679
Healthy eating behavior factor	−0.21 ± 1.19[a]	0.11 ± 0.93	7.62	0.006	−0.12 ± 1.06	−0.02 ± 0.98[a]	1.58	0.210
Protein eating behavior factor	0.12 ± 1.20[a]	0.10 ± 1.01	4.58	0.033	0.05 ± 1.13	−0.19 ± 0.83[a]	14.07	< 0.001
Wanting to be the opposite gender			110.43	< 0.001			123.09	< 0.001
Yes	46 (63.9)	23 (8.4)			73 (79.3)	31 (14.2)		
No	26 (36.1)	252 (91.6)			19 (20.7)	187 (85.8)		

[a]Boys with disliking their own gender (including not completely like or dislike) vs. girls with liking their own gender, $P < 0.05$; [b]girls with disliking their own gender (including not completely like or dislike) vs. boys with liking their own gender, $P < 0.05$.

girls who wanted to be of the opposite gender and boys who did not want to be of the opposite gender ($P > 0.05$) (see Table 5 for details).

Interactions between disliking your own gender and wanting to be the opposite gender in eating behaviors

After adjusting for age, overall obesity and abdominal obesity, each eating behavior was treated as a dependent variable. Disliking one's own gender (yes = 1, no = 0), wanting to be the opposite gender (yes = 1, no = 0), and the interaction item between disliking one's own gender and wanting to be the opposite gender were used as independent variables. Multiple linear regressions were performed using a stepwise method. The results showed that disliking one's own gender positively correlated with unhealthy eating behavior and negatively correlated with eating fresh vegetables in boys ($P < 0.05$). There was a significant interaction between disliking one's own gender and wanting to be of the opposite gender predicting midnight snack consumption ($P < 0.05$). Disliking one's own gender positively correlated with eating western fast food and unhealthy eating behavior in girls ($P < 0.05$). Wanting to be the opposite gender negatively correlated with eating western fast food and unhealthy eating behavior in girls ($P < 0.05$). There were positive interactions between disliking one's own gender and wanting to be the opposite gender that predicted consumption of carbonated drinks, fish, meat, and shrimp and high protein eating among girls ($P < 0.05$) (see Table 6 and Figure 2 for details).

Discussion

It is common for children and adolescents to have negative gender attitudes (disliking their own gender or wanting to be the opposite gender) and unhealthy eating behaviors, and adolescence is an important stage in the formation of gender role orientation and healthy eating behaviors. This study reported

TABLE 5 Comparisons of differences in eating behaviors between children and adolescents with wanting to be opposite gender and no wanting to be opposite gender.

Variables	Wanting to be the opposite gender in boys		t/X^2	*P*	Wanting to be the opposite gender in girls		t/X^2	*P*
	Yes (*n* = 69)	No (*n* = 278)			Yes (*n* = 104)	No (*n* = 206)		
Dine out	2.5 ± 2.4	2.2 ± 2.3	1.22	0.270	1.7 ± 2.0	1.9 ± 2.2	0.87	0.351
Breakfast	6.1 ± 1.9	6.2 ± 1.7	0.80	0.371	5.9 ± 1.9	5.8 ± 2.1	1.32	0.252
Midnight snack	2.3 ± 2.8[a]	1.7 ± 2.6	2.29	0.131	1.2 ± 2.3	1.5 ± 2.5[a]	2.87	0.094
Fried food	2.0 ± 2.3	2.0 ± 2.1	0.85	0.356	2.0 ± 2.1	1.8 ± 2.1	0.00	0.973
High-calorie snacks	2.2 ± 2.6[a]	2.0 ± 2.2	7.52	0.006	2.0 ± 2.1	2.1 ± 2.2[a]	2.23	0.136
Western fast food	1.3 ± 2.2[a]	0.9 ± 1.7	9.92	0.002	0.7 ± 1.4	0.8 ± 1.6[a]	1.05	0.307
Carbonated drink	1.7 ± 2.3	1.4 ± 1.9	3.75	0.054	1.0 ± 1.7	0.8 ± 1.4	3.49	0.063
Preserved vegetables	2.3 ± 2.5[a]	1.9 ± 2.2	4.80	0.029	1.6 ± 2.1	1.5 ± 2.1[a]	0.11	0.738
Fish meat	2.6 ± 2.3	2.7 ± 2.3	0.17	0.684	2.3 ± 2.4	2.0 ± 2.1	5.20	0.023
Shrimps	1.7 ± 2.3	1.7 ± 2.2	0.07	0.791	1.8 ± 2.3	1.4 ± 1.7	8.23	0.004
Eggs	4.5 ± 2.7	4.9 ± 2.4[b]	4.57	0.033	4.4 ± 2.8[b]	4.7 ± 2.6	4.13	0.043
Milk	5.4 ± 2.1	5.5 ± 1.2	0.42	0.517	5.2 ± 2.3	5.4 ± 2.3	0.03	0.855
Fresh vegetables	5.0 ± 2.6[a]	5.4 ± 2.2	4.56	0.033	5.4 ± 2.2	5.5 ± 2.2[a]	0.25	0.616
Fruits	5.1 ± 2.5[a]	5.8 ± 1.9	14.00	< 0.001	5.4 ± 2.3	5.5 ± 2.1[a]	0.76	0.384
Unhealthy eating behavior factor	0.27 ± 1.31[a]	0.05 ± 0.97	11.64	0.001	−0.14 ± 0.90	−0.09 ± 0.90[a]	0.54	0.462
Healthy eating behavior factor	−0.12 ± 1.17	0.08 ± 0.95	4.17	0.042	−0.09 ± 1.04	−0.02 ± 0.99	0.67	0.415
Protein eating behavior factor	0.10 ± 1.15	0.11 ± 1.02	2.12	0.147	0.02 ± 0.90	−0.19 ± 0.85	6.32	0.012

[a]Boys who wanted to be opposite gender (including wanting and not completely wanting) vs. girls who did not want to be opposite gender, $P < 0.05$; [b]girls who wanted to be opposite gender (including wanting and not completely wanting) vs. boys who did not want to be opposite gender, $P < 0.05$.

the characteristics of negative gender attitudes and eating behavior among Chinese children and adolescents and revealed the relationships between negative gender attitudes and eating behaviors for the first time, to our knowledge. The study found that boys who did not like their gender or wanted to be the opposite gender had more unhealthy eating behaviors, while they had fewer healthy eating behaviors; Girls who did not like their gender or wanted to be the opposite gender had more protein eating behaviors.

The results of this study showed that 6.5% of children disliked their own gender, 8.8% of children wanted to be of the opposite gender, and the proportion of girls with negative gender attitudes was higher than that of boys. Steensma et al. (24) estimated that the incidence of persistent gender dysphoria from childhood to adolescence ranges from 2 to 27%. Cohen-Kettenis et al. (25) confirmed that girls had a higher tolerance for transgender behaviors. Zhang et al. (26) reported that girls were more dissatisfied with their gender than boys. Social culture may play an important role in negative gender attitudes. Zucker et al. (27) found that boys' feminine behaviors were less accepted than girls' masculine behaviors. This study showed that the proportion of children with abdominal obesity and overall obesity was 29.8 and 31.5%, respectively, and was higher in boys than in girls, which may be related to the fact that boys ate breakfast, midnight snacks, preserved vegetables, western fast food, carbonated drinks, fish, meat, and shrimp more frequently and expressed more unhealthy dietary behaviors and more protein dietary behaviors than girls. A study found that boys were twice as likely to be overweight as girls, and that boys' less healthy eating habits were associated with higher daily intake of protein-rich foods (28). Previous studies have proven that girls are more likely than boys to skip midnight snacks, eat more fruits and drink fewer carbonated drinks (29).

We found that boys who disliked their own gender or who wanted to be the opposite gender expressed more unhealthy eating behaviors and fewer healthy eating behaviors; girls who disliked their own gender had more frequent unhealthy eating behaviors. Becker et al. (30) reported that people with gender dysphoria suffered from eating disorders due to dissatisfaction with their gender-related body parts, inner distress and inability to accept them. Studies have shown that male sexual minorities may have lower diet quality and worse eating habits than non-minorities (31). Transgender individuals conceal or demonstrate their specific gender characteristics by unhealthy eating behaviors (32). Ålgars et al. (33) found that transgender persons try to conceal the characteristics of

TABLE 6 The results of multiple linear regression on associations between eating behaviors and negative gender attitude after adjusting for age, overall obesity and abdominal obesity.

Gender	Dependent variables	Independent variables	*B*	SE	Beta	*t*	*P*
Boys	Midnight snack	Disliking your own gender	0.06	0.76	0.45	0.04	0.395
		Wanting to be opposite gender	−0.05	−0.53	0.60	−0.03	0.384
		Disliking your own gender × wanting to be opposite gender	0.93	0.41	0.12	2.23	0.026
	Fresh vegetables	Disliking your own gender	−0.74	0.30	−0.13	−2.42	0.016
		Wanting to be opposite gender	0.05	0.78	0.44	0.04	0.681
		Disliking your own gender × wanting to be opposite gender	−0.02	−0.29	0.77	−0.02	0.411
	Unhealthy eating behavior factor	Disliking your own gender	0.28	0.14	0.11	2.04	0.043
		Wanting to be opposite gender	−0.01	−0.19	0.85	−0.01	0.681
		Disliking your own gender × wanting to be opposite gender	−0.02	−0.18	0.85	−0.01	0.411
Girls	Western fast food	Disliking your own gender	0.72	0.23	0.22	3.08	0.002
		Wanting to be opposite gender	−0.46	0.23	−0.14	−1.99	0.048
		Disliking your own gender × wanting to be opposite gender	−0.11	−0.83	0.41	−0.05	0.170
	Carbonated drink	Disliking your own gender	0.06	0.53	0.60	0.03	0.268
		Wanting to be opposite gender	−0.00	−0.01	1.00	0.00	0.385
		Disliking your own gender × wanting to be opposite gender	0.44	0.20	0.12	2.16	0.031
	Fish meat	Disliking your own gender	0.01	0.09	0.93	0.01	0.268
		Wanting to be opposite gender	−0.09	−1.01	0.31	−0.06	0.385
		Disliking your own gender × wanting to be opposite gender	0.66	0.29	0.13	2.25	0.025
	Shrimps	Disliking your own gender	−0.00	−0.01	1.00	0.00	0.268
		Wanting to be opposite gender	0.04	0.47	0.64	0.03	0.385
		Disliking your own gender × wanting to be opposite gender	0.65	0.26	0.14	2.51	0.013
	Unhealthy eating behavior factor	Disliking your own gender	0.42	0.15	0.21	2.86	0.005
		Wanting to be opposite gender	−0.30	0.14	−0.15	−2.04	0.042
		Disliking your own gender × wanting to be opposite gender	−0.05	−0.34	0.73	−0.02	0.170
	Protein eating behavior factor	Disliking your own gender	−0.02	−0.14	0.89	−0.01	0.268
		Wanting to be opposite gender	0.01	0.12	0.90	0.01	0.385
		Disliking your own gender × wanting to be opposite gender	0.34	0.12	0.16	2.76	0.006

Disliking your own gender × wanting to be opposite gender: Interaction item between disliking one's own gender and wanting to be the opposite gender.

their assigned sex or demonstrate the characteristics of their required gender identity through changes in dietary behavior. The common gender stereotypes of parents often teach boys to change their feminine characteristics or behaviors, and poor teaching may increase boys' psychological burden and unhealthy eating behaviors (34). Sociocultural pressure may increase the risk of disordered weight control behaviors (such as unhealthy eating behaviors) for gender-non-conforming girls (35). Adolescents with non-conforming gender expression in school and online environments are more likely to experience peer bullying and peer violence (36, 37) and may have an increased risk for disordered weight control behaviors (38). The greater the social pressure of children who want to be of the opposite gender, the more serious unhealthy eating behaviors may be (11).

In addition, we found that boys who disliked their own gender had more protein eating behaviors. Studies have shown that boys are more likely to have strong muscles, while girls are more likely to have slim bodies (39). Muscle strength is an important determinant of physical performance in children and adolescents (40). Boys who do not like their gender might feel that way because they are not strong enough and thus hope to become strong through higher protein eating behavior (41). Men's pursuit of muscle is also an internal social and cultural pressure, which suggests that men should have a muscular body (42). However, we found that there were not more protein eating behaviors among boys who wanted to be the opposite gender, and there were no differences in healthy eating behaviors between boys who wanted to be the opposite gender and girls who did not, which shows that boys who want to be the opposite

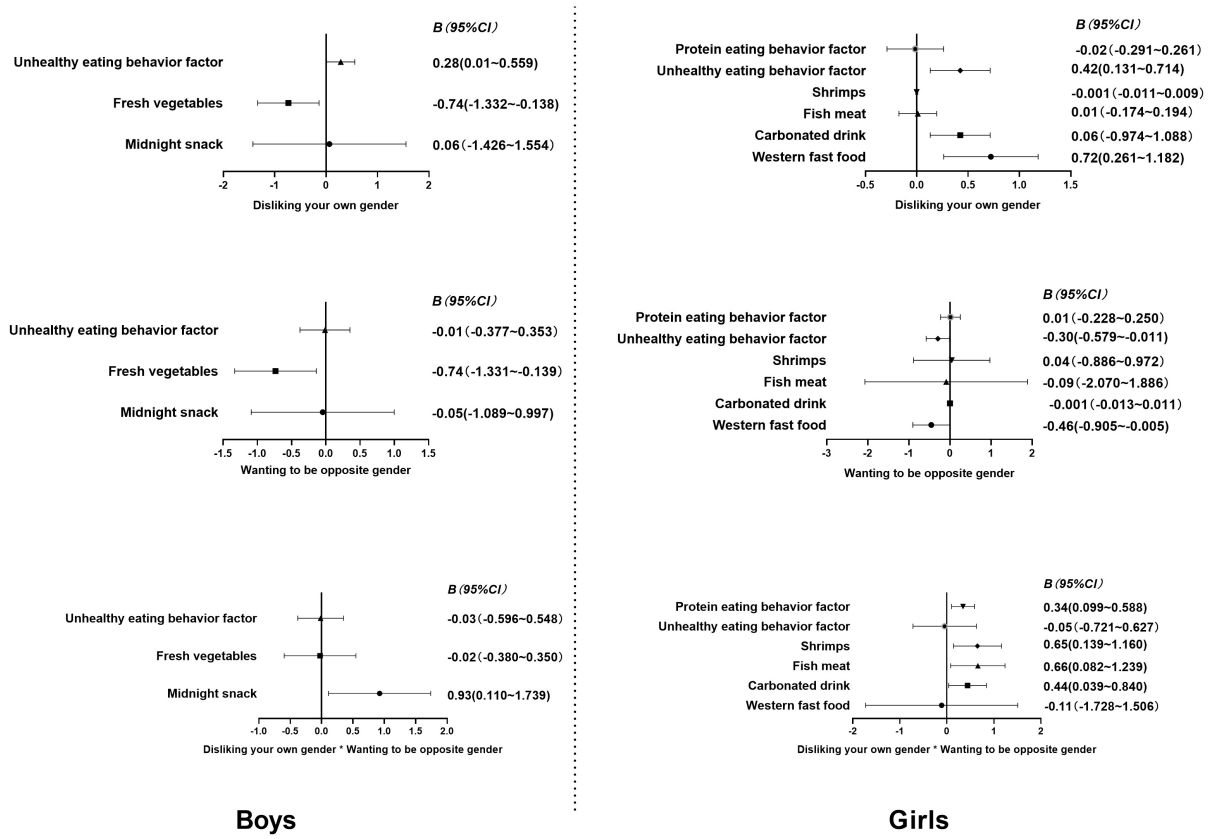

FIGURE 2
95% CI of association coefficients between eating behaviors and negative gender attitude.

gender may not make themselves stronger, but their goal may be to make themselves more like girls through healthy eating behaviors. Studies have shown that boys who want to be the opposite gender still want to have large hips and breasts despite their healthy weight (43). Homosexual men pay more attention to thin bodies (11). We found that girls who disliked their own gender or who wanted to be the opposite gender had higher protein eating behavior, and there was no difference from boys who liked their gender or did not want to be the opposite gender. Girls who did not like their gender might not be slim enough, but they wanted to make themselves into boys through higher protein eating behaviors, which is in line with the femininity hypothesis (44). In addition, the results of multiple linear regression showed that girls who wanted to be of the opposite gender had fewer unhealthy eating behaviors than girls who did not want to be of the opposite gender, which shows that girls with this desire are more motivated to develop toward the opposite sex through eating behaviors. We found that there was a positive interaction between disliking one's own gender and wanting to be the opposite gender in boys' midnight snack eating and in girls' consumption of carbonated drinks, fish, meat, and shrimp and their protein dietary factors, which indicates that if a child does not like their own gender and has the desire to become the opposite gender at the same time, the above eating behaviors will be more frequent.

This study has several limitations. First, based on a cross-sectional study, we found relationships between negative gender attitudes and eating behaviors; however, whether the correlations are causal remains to be verified by cohort studies. Second, the children and adolescents surveyed were from two primary and secondary schools in China, which has limitations in extending other adolescents. Finally, all the collected data were the participants' self-reports, and their responses may be affected by factors such as denial, idealization and social expectations.

Conclusion

The proportion of girls with a negative gender attitude (disliking their own gender or wanting to be the opposite gender) was higher than that of boys. Boys who disliked their own gender or wanted to be the opposite gender may have higher frequencies of unhealthy eating behaviors and lower frequencies of healthy eating behaviors. Girls who disliked their own gender or wanted to be the opposite gender may

have higher frequencies of protein eating behaviors. While encouraging children to develop healthy eating behaviors, we should pay attention to children's positive attitudes toward their own gender cognition.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Medical Research Ethics Committee of Bengbu medical college [(2015) No. 003]. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

RC and JC: conceptualization. KL, YW, XP, and JZ: methodology. RC: formal analysis and data curation. LF, RY, and HH: investigation. RC and LF: writing — original draft preparation and writing — review and editing. MH, RY, and HH: visualization. LF: project administration. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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A cross-sectional exploratory study of food literacy among Saudi parents of adolescent children aged 10 to 19 years

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Introduction: Parental food literacy is fundamental in laying a solid foundation for healthy eating among their children. This study aimed to (1) evaluate the current state of food literacy among Saudi parents of 10-19 years old adolescent children, and (2) determine the correlates associated with parental food literacy.

Methods: This cross-sectional study was conducted between April and June 2022, with a convenience sample of 1845 Saudi parents (mean age = 45.1 ± 11; mothers: 56%). A Short Food Literacy Questionnaire (SFLQ) was used to meet the study aims.

Results: Findings showed that around 46% of parents had poor food literacy. Fathers were 2.4 times more likely than mothers to be food illiterate (OR = 2.4, CI = 1.9–3.0, $p < 0.001$). Parents residing in Riyadh, Northern borders, Jawf, or Ha'il had a three times higher risk of being food illiterate than those residing in other provinces (OR = 3.2, CI = 2.6–3.9, $p < 0.001$). Parental overweight or obesity increased their risk of being food illiterate by 60% (OR = 1.6, CI = 1.3–2.1, $p < 0.001$). Healthy parents, in contrast to those having a chronic disease (s), had a 60% higher probability of food illiteracy (OR = 0.4, CI = 0.3–0.6, $p < 0.001$). Educated parents had a three times higher risk of being food illiterate (vs. uneducated parents, OR = 3.0, CI = 1.6–5.8, $p = 0.001$). Parents making less than 3000 Saudi Riyal (SR) per month (<798 USD/779 EUR) were 40% more likely to be food illiterate than those who reported 3000-25000 SR (798–6652 USD/779–6499 EUR) (OR = 0.6, CI = 0.4–0.9, $p = 0.02$), and 70% more likely to be food illiterate than those making more than 25000 SR (>6652 USD/6497 EUR) (OR = 0.3, CI = 0.2–0.6, $p < 0.001$). Parents who lived in crowded households were twice as likely to be food illiterate as those who did not (OR = 1.9, CI = 1.5–2.4, $p < 0.001$).

Conclusion: The current study findings should be employed in future programming and policy-making approaches to reach Saudi parents for

necessary food literacy interventions. These interventions could include bolstering their confidence while cooking, buying groceries, reading nutrition labels, and integrating them into nutrition education lessons with their children in school settings.

KEYWORDS

parental, food literacy, Saudi, parents, correlates

1. Introduction

Food literacy is a construct that affects an individual's ability to comprehend food and nutrition information, understand food labels, practice food safety precautions, cook healthily and safely, and adhere to dietary recommendations in their food choices (1, 2). A food-literate person makes decisions to support the achievement of personal health and a sustainable food system considering environmental, social, economic, cultural, and political components (3). It is "the scaffolding term that empowers individuals, households, communities, or nations to protect diet quality through change and strengthen dietary resilience over time" (4). In the early 90s, food literacy was first defined to exemplify a person's functional ability to maintain a nutritious diet without being deprived (5). Since then, food literacy topics have evolved over the years and have caught the interest of nutrition researchers (6). In the Middle East and North Africa (MENA) region, individuals' food literacy predicted their food habits, food label use, food consumption patterns, school performance, dietary diversity, nutrient adequacy, and food security (6). According to the Food and Agricultural Organization (FAO), nearly one-third of Arabs were food insecure in 2020 (7). Additionally, between 2014 and 2020, the number of undernourished people in the Arab world increased by 30%, reaching 69 million (7). By 2030, there will likely be more than 75 million undernourished Arab people (7). The prevalence of obesity increased concurrently to 28.8% in 2020, more than double the global average of 13.1%, placing the Arab region as the third most obese in the world (7).

Saudi Arabia has progressed somewhat toward its diet-related goals for preventing and controlling non-communicable diseases (NCD) (8). In accordance with the 2025 global nutrition goals, Saudi Arabia attempted to prevent a rise in childhood obesity, and its efforts to prevent noncommunicable diseases centered on limiting people's exposure to modifiable risk factors (8). With an estimated 34.3% of adult men and 45.5% of adult women living with obesity, the country has made little progress toward its obesity prevention goal (8). During the upcoming years, it is anticipated that the prevalence of adolescent obesity in Saudi Arabia will continue to rise. The latter claim is backed by frequent observations of Saudi adolescents' fast-food consumption, skipping breakfast, and minimal consumption of fruits and vegetables (9).

After infancy, the adolescent years (about 10–19) provide a second, equally important opportunity to foster healthy growth and maturation (10). The fast physical growth during adolescence is known as the pubertal growth spurt (11), accounting for about 20–25% of the final adult height (11). Moreover, adolescents potentially gain 50% of their ideal body weight in this growth spurt (11). Positive environments and relations can improve developmental outcomes during this time, while the effects of negative experiences can be amplified and last into adulthood (10). Parents are crucial in determining how teenagers respond to the various elements that define their development (12). As children progress into adolescence, the parenting relationship changes, and parents need different developmentally-appropriate skills and tactics to meet the needs of their children (12). Adequate parental support improves adolescents' developmental outcomes and can mitigate the influence of unfavorable external factors (12). Additionally, the impact of parenting practices might outlast generations (12). Parenting programs are, broadly, "a combination of activities or services designed to improve how parents approach and carry out their parental role specifically their parenting knowledge, attitudes, skills, and practices" (10).

Parents can influence their children's evolving food preferences and eating habits by making certain foods more accessible than others and portraying themselves as eating behavior models (13). As the family's gatekeepers, parents should have adequate food literacy knowledge and skills (13). Food-illiterate parents fail to model healthy family habits, worsening when parents face financial challenges that limit their access to food (13). Two aspects of food literacy, nutritional awareness and the ability to conceptualize food, were highly connected with the quality of the family's diet (14). Children whose parents were knowledgeable about healthy diets tend to be healthier and less overweight (14). Their diets consisted primarily of vegetables, white fish, eggs, micronutrients, and proteins, with fewer servings of meat and fewer sugar-sweetened beverages (14). Teens who said their parents helped them make healthy food choices and kept a close eye on their food choice

tended to have better diets (15). Since a great deal of data on how parenting affects a child's health and nutrition during adolescence already exists, current research focuses on parents with adolescent children. These facts suggest that improving Saudi parents' food literacy could be a promising first step in resolving our nation's current nutrition challenges, especially during the nutritionally vulnerable adolescent stage. Thus, to guide future interventions, this study was conducted as the first in Saudi Arabia to (1) evaluate the food literacy of Saudi parents of 10–19 years old adolescent children and (2) determine the correlates associated with parental food literacy.

2. Materials and methods

2.1. Study design and participants' recruitment

Following a cross-sectional design and the convenience snowball sampling method, this study was conducted between 29 April and 6 June 2022. Data were collected from 1,845 Saudi parents using an online-based self-administered questionnaire. The survey link was kept open on different social media platforms (e.g., Facebook, Instagram, Twitter, Pinterest, and LinkedIn) to be filled out by eligible participants. Additionally, the author posted the survey link on public and private schools' websites and WhatsApp groups to reach a larger sample of parents with diverse socio-demographic characteristics and age categories. Since older parents might not have internet access, the author asked their children or other family members to introduce them to the study's aims, aiding them while responding to the survey questions when necessary. The eligibility criteria for study participants were the following: (1) being a parent for 10–19 years old adolescent children, (2) being older than 18 years old, and (3) having Saudi nationality. The age of children was decided per the World Health Organization's (WHO) recommendations, which classify this age range (10–19 years) as the adolescent stage of life (16). To better generalize the findings, parents were recruited from almost all Saudi provinces: Riyadh, Makkah, Madinah, Eastern province, Northern borders, Jawf, Tabuk, Ha'il, Qasim, Bahah, Asir, and Najran.

2.2. Study variables

2.2.1. Explanatory variables

Using a validated questionnaire, I collected information on the following parents' socio-demographic characteristics: age, gender, current location, marital status (married, divorced, and widowed), number of children the parents have (sons and daughters), education level, spouses' education level, job status (unemployed, full-time job, part-time job, and self-employed), family monthly income, the number of co-residents in the home (excluding newborns) with the number of rooms (without counting the kitchen and the bathroom) to assess the households' crowding status. In addition, parents were asked to report any chronic disease(s) they had. Self-reported body weight and height were also collected to evaluate parents' weight status following the WHO's Body Mass Index (BMI) cutoff criteria (17). Based on these criteria, BMI falls into one of the following categories for persons over 20 years of age: underweight (BMI $<$ 18.5 kg/m^2), normal-weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (30 kg/m^2 and above).

2.2.2. Outcome variable

The outcome variable of interest for this study was the parents' food literacy status. Thus, a valid short food literacy questionnaire (SFLQ) (18) was used to evaluate respondents' perceived level of food literacy. As shown in **Table 1**, six of the 12 self-rated items asked about functional skills like understanding nutrition information and composing a balanced menu. Two items asked about interactive abilities like exchanging nutrition information with family and peers. The remaining four items inquired about critical judgment skills, such as evaluating the longer-term impact of dietary habits on health (critical FL). Respondents were given four- or five-point Likert scales with options ranging from very bad to very good, strongly disagree to strongly agree, very hard to very easy, or never to always. The questionnaire had a score ranging from 7 to 52. A higher score suggests better food literacy. The median score of 30 was used to categorize parents into two groups based on their food literacy status. A score of less than 30 indicated poor food literacy, and a score of 30 and above indicated adequate food literacy among parents in this study.

Although the questionnaire was based on a previously validated survey (18), it was nonetheless subjected to a face validity (or "logic validity") evaluation to ensure its accuracy. An expert panel consisting of a public health nutritionist and four registered dietitians assessed each survey question separately. The questionnaire was double-checked to ensure it captured essential aspects of food literacy, including the ability to do basic tasks, communicate with others, and make sound judgments. A statistician [an accredited practicing dietitian (APD) and an expert on question structure] checked the survey for typical mistakes (e.g., leading, confusing, or double-barreled questions). To begin, two nutritionist researchers from Taibah University's Department of Applied Medical Science served as pilot respondents for the study. After this, 10 parents of children aged 10–19 were recruited as a convenience sample to pilot test the survey and provide feedback on its length, clarity, and usability. This helped establish how long the average parent would take to complete the questionnaire. As a result, revisions were made to some of the existing questions to accommodate society and Saudi recommendations.

TABLE 1 Parental self-rated food literacy questionnaire.

Questions	Dimension	Min-Max score
1. When I have questions on nutrition, I know where I can find information on the issue.	Functional food literacy (FFL)	Disagree strongly = 1 to Agree strongly = 4; I do not have experience with these issues = 0
2. In general, how well do you understand the following types of nutritional information? (A) Nutrition information leaflets (B) Food label information (C) TV or radio programs on nutrition (D) Oral recommendations regarding nutrition from professionals. (E) Nutrition advise from family members or friends	Functional food literacy	Very bad = 1 to Very good = 5; I do not make use of this kind of information = 0
3. How familiar are you with The Healthy Food Palm (Food-based dietary guidelines), the Saudi Healthy Plate Guide, or the Healthy Food Guide for the Healthy Practitioner?	Functional food literacy	Very bad = 1 to Very good = 5
4. I know the official Saudi recommendations about fruit and vegetable consumption	Functional food literacy	Disagree strongly = 1 to Agree strongly = 4
5. I know the official Saudi recommendations about salt intake	Functional food literacy	Disagree strongly = 1 to Agree strongly = 4
6. Think about a usual day; how easy or difficult is it for you to compose a balanced meal at home?	Functional food literacy	Very hard = 1 to very easy = 4; not applicable = 0
7. In the past, how often were you able to help your family members or a friend if they had questions concerning nutritional issues?	Interactive food literacy (IFL)	1 = Never to always = 5; there have never been any questions = 0
8. There is a lot of information available on healthy nutrition today. How well do you manage to choose the information relevant to you?	Interactive food literacy (IFL)	Very bad = 1 to Very good = 5; I have not been interested in these issues = 0
9. How easy/difficult is it for you to judge if media information on nutritional issues can be trusted?	Critical food literacy (CFL)	Very difficult = 1 to very easy = 4
10. Commercials often relate foods with health. How easy/hard is it for you to judge if the presented associations are appropriate or not?	Critical food literacy (CFL)	Very hard = 1 to very easy = 4
11. How easy/hard is it for you to evaluate if a specific food is relevant for a healthy diet?	Critical food literacy (CFL)	Very hard = 1 to very easy = 4
12. How easy/hard is it for you to evaluate the longer-term impact of your dietary habits on your health?	Critical food literacy (CFL)	Very hard = 1 to very easy = 4

2.3. Ethical approval of the study protocol

The current study protocol was approved by the ethical committee of Taibah University (TU), Saudi Arabia. I adhered to the Helsinki declaration principles developed by the World Medical Association while conducting this study. Hence, all parents provided their consent to participate, verbally and electronically, before filling out the first page of the online survey. There were no risks associated with participation in this study, which was voluntary.

2.4. Data analysis

The collected data was exported to the Statistical Package of Social Sciences Software (SPSS) (Version 25.0. IBM Corp: Armonk, NY, USA) for analysis. A "weighting" variable was created to enhance the sample's representation according to gender and current location. Descriptive measures, including frequency (N), percentage (%), mean, and standard deviation (SD), were obtained to summarize the study findings. The continuous variables' normal distribution was checked using the Shapiro–Wilk test. The Mann–Whitney *U* test was used to detect mean differences between study variables composed of two groups. The chi-squared test (χ^2) was used to identify significant associations between the explanatory variables (such as age, gender, education level, and health status) and the outcome variable of the study (food literacy). Furtherly, a multivariate analysis using the backward stepwise method of the binary logistic regression was used to point out the most significant determinants of parents' food literacy. A *p*-value of 0.05 and below was considered significant for all analytical tests.

3. Results

3.1. Parental socio-demographic characteristics and health status

Overall, this study included a total of 1,845 Saudi parents. Of them, 56% were mothers. The overall mean age of parents was 45.1 ± 11.0. Participants were recruited from almost all Saudi provinces. More than half of the parents (57%) were overweight or obese. Most parents (84.9%) were currently married, and 65.6% had 2–3 children. Furthermore, most (64.5%) had a university education level, and 45.6% of the parents reported working full-time. Additionally, 53% of the

participants made 3,000–10,000 Saudi Riyal (SR) per month (equivalent to 799–2,661 USD or 779–2,598 EUR). Roughly 39.7% of the parents' households were either crowded or overcrowded. As for their health status, 29.3% had one or more chronic diseases (Table 2).

3.2. Parental food literacy status and its correlates

Nearly half the parents (46%) had poor food literacy scores. The correlates associated with parental food literacy are shown in Table 3. The mean age of food-illiterate parents (46 ± 10) was higher than those with adequate food literacy levels (45 ± 12), $p = 0.02$. Father participants (58.6%) were more food illiterate than mothers (36.1%), $p < 0.001$. More than half the participants residing in Riyadh (54.8%), Northern borders (100%), Jawf (78.3%), and Ha'il (60%) had poor food literacy scores, $p < 0.001$. The majority of obese parents (66.6%) had poor food literacy scores, exceeding that reported among parents with different weight statuses, particularly underweight (24%), $p < 0.001$.

Also, 48.8% of parents with a university education level were food illiterate compared to those who reported a lower education level [school education (42.9%) or having no formal education (24.1%)], $p < 0.001$. Around half (50.4%) of employed parents (full-time, part-time, and self-employed) had poor food literacy compared to unemployed parents (39.2%), $p < 0.001$. Roughly 49.9% of parents who reported having no income or lower than 3,000 SR monthly income had poor food literacy scores, $p = 0.002$. The prevalence of food illiteracy was highest among healthy parents (51.7%), as opposed to 32.2% of parents having one or more chronic diseases. Parents living in crowded households had higher levels of food illiteracy than those who were not (60.5 vs. 36.4%, p 0.001). Parental marital status and the number of children the parents have shown no significant associations with parental food literacy ($p = 0.21$ and $p = 0.42$, respectively) (Table 3).

3.3. The determinants of parental food literacy: Binary logistic regression analysis

Table 4 demonstrates that fathers were 2.4 times more likely than mothers to be food illiterate (OR = 2.4, CI = 1.9–3.0, $p < 0.001$). Parents residing in Riyadh, Northern borders, Jawf, or Ha'il provinces had a risk of poor food literacy that was three times higher than those living in other Saudi provinces (OR = 3.2, CI = 2.6–3.9, $p < 0.001$). Obese/overweight parents had a 60% higher risk of being food illiterate (vs. underweight parents OR = 1.6, CI = 1.3–2.1, $p < 0.001$). Healthy parents (reference), compared to those having one or more chronic diseases, had a 60.0% higher probability of having poor food literacy (OR = 0.4, CI = 0.3–0.6, $p < 0.001$).

Added to these, educated parents (with school or university education levels) had triple the risk of being food illiterate compared to their counterparts who have no formal education (OR = 3, CI = 1.6–5.8, $p < 0.001$). Parents making less than 3,000 Saudi Riyal (SR) per month were 40% more likely to be food illiterate than those who reported 3,000–25,000 SR (OR = 0.6, CI = 0.4–0.9, $p = 0.02$), and 70.0% more likely to be food illiterate than those making more than 25,000 SR (OR = 0.3, CI = 0.2–0.6, $p < 0.001$). Parents living in crowded households had doubled the risk of food illiteracy compared to those who were not (OR = 1.9, CI = 1.5–2.4, $p < 0.001$) (Table 4).

4. Discussion

A person's level of food literacy is a significant factor in determining how well they can maintain a healthy nutrition status (5). Consequentially, academics and various stakeholders in the healthcare industry increasingly regard nutritional literacy as an essential component in health promotion (19). To the best of the author's knowledge, this population-based, cross-sectional study is the first to evaluate parents' food literacy and the factors that influence it in Saudi Arabia. The study respondents included 1,845 parents (the mean age was 45.1 ± 11.0, and 56% were mothers); I found that nearly half (46%) had poor food literacy scores. The binary logistic regression analysis showed that parental gender, residence, weight status, health status, job status, education level, monthly income, and household crowding status were the most significant factors contributing to the determination of parental food literacy in this study.

4.1. Parental food literacy and potential intervention programs

According to the survey results, nearly half of the parents (46%) had low levels of food literacy. This result is consistent with a recent literature review on testing food literacy in the Middle East and North Africa (MENA) area, which found that most people in these countries had inadequate food and/or nutrition literacy, particularly in the domain of skills rather than cognition (6). It appears that the current food literacy status of Saudi parents is worse than that observed in Canada, where most parents had good food literacy competencies, manifested by selecting foods based on nutrition labels (81%), planning meals before going to the market (91%) using grocery lists (95%), cooking with whole and basic ingredients (66.6%), and having advanced cooking skills (66.6%) (20). Like food literacy, nutrition literacy is "the degree to which people can obtain, process, and understand basic diet information and the tools

TABLE 2 Parental socio-demographic characteristics and health status.

	Overall (N = 1,845)		Females (n = 1,034)		Males (n = 811)		P-value
	Mean ± SD		Mean ± SD		Mean ± SD		
Age in years	45.1 ± 11.0		42.0 ± 11.0		49.0 ± 9.0		**<0.001**
	N	%	*N*	%	*N*	%	
Location							<0.001**
Riyadh	178	9.6	80	7.8	98	12.0	
Makkah	170	9.2	82	7.9	88	10.8	
Madinah	166	9.0	85	8.2	81	10.0	
Eastern province	241	13.1	55	5.3	186	22.9	
Northern borders	53	2.9	53	5.1	0	0.0	
Jawf	245	13.3	53	5.1	192	23.7	
Tabuk	130	7.0	98	9.4	32	3.9	
Ha'il	133	7.2	133	12.9	0	0.0	
Qasim	149	8.1	90	8.7	59	7.3	
Bahah	148	8.0	100	9.6	48	5.9	
Asir	126	6.8	99	8.6	27	3.4	
Najran	106	5.8	106	10.3	0	0.0	
Weight status (n = 1,778)[a]							<0.001**
Underweight	87	4.7	65	6.6	22	2.7	
Normal-weight	639	34.6	435	44.3	203	25.6	
Overweight	537	29.1	294	29.9	243	30.6	
Obese	515	27.9	188	19.1	327	41.1	
Marital status							<0.001**
Married	1,565	84.9	849	82.2	716	88.3	
Divorced	101	5.5	47	4.6	54	6.7	
Widowed	178	9.6	137	13.3	40	5.0	
Number of children							0.04*
One child	275	14.9	156	15.1	120	14.7	
2–3	359	19.5	222	21.4	138	17.0	
>3	1,211	65.6	656	63.5	553	68.3	
Education level							<0.001**
No formal education	72	3.9	63	6.1	8	1.0	
Elementary school level	93	5.0	37	3.6	56	6.9	
Intermediate school level	241	13.0	205	19.8	36	4.4	
Secondary school level	249	13.5	127	12.3	122	15.0	
University level	1,190	64.5	601	58.2	589	72.6	
Job status							<0.001**
Unemployed	727	39.4	565	54.6	162	20.0	
Full-time job	841	45.6	369	35.7	471	58.1	
Part-time job	118	6.4	49	4.8	68	8.4	
Self-employed	159	8.6	50	4.9	109	13.5	
Monthly income							<0.001**
None	72	3.9	52	5.0	20	2.4	
Less than 3,000 SR (<799 USD$/779 euro €)	82	4.5	38	3.6	44	5.5	
3,000–10,000 SR (equivalent to 799–2,661 USD$/779–2,598 euro €)	977	53.0	597	57.8	380	46.9	
10,000–25,000 SR (equivalent to 2,661–6,652 USD $/2,597–6,497 euro €)	570	30.9	270	26.1	301	37.1	
More than 25,000 SR (>6,652 USD$/6,497 euro €)	143	7.8					
Household crowding index							<0.001**
≤1[b]	1,113	60.3	683	66.1	429	53.0	
>1[c]	468	25.4	172	16.7	295	36.5	
>1.5[d]	264	14.3	178	17.2	86	10.6	

(Continued)

TABLE 2 (Continued)

	Overall (N = 1,845)		Females (n = 1,034)		Males (n = 811)		P-value
	Mean ± SD		Mean ± SD		Mean ± SD		
Age in years	45.1 ± 11.0		42.0 ± 11.0		49.0 ± 9.0		**<0.001**
	N	%	*N*	%	*N*	%	
Prevalence of chronic diseases (n = 540; among diseased parents)							
Cardiovascular diseases (CVD)	25	3.2	7	1.9	18	4.3	0.04*
Diabetes	217	28.1	62	17.3	155	37.4	<0.001**
Hypertension	217	28.0	65	18.1	152	36.7	<0.001**
Chronic kidney diseases (CKD)	6	0.8	2	0.6	4	1.0	0.26
Liver diseases	23	3.0	21	5.9	2	0.5	0.001*
Osteoporosis	8	1.0	7	1.9	1	0.2	0.07
Cancer	11	1.4	1	0.3	9	2.2	0.003*
Respiratory diseases	79	10.2	23	6.4	56	13.5	<0.001**
Anemia	130	16.8	114	31.8	16	3.9	<0.001**
Others	57	7.4	56	15.6	1	0.2	<0.001**

[a]Some parents did not report their body weight, and this is why some data were missing; [b]no crowding; [c]crowded; [d]over-crowded; *significant at p-value < 0.05 for χ^2 test; **significant at p-value < 0.001 for χ^2 test; bold value was significant based on the Mann–Whitney U test.

needed to make appropriate nutrition decisions" (21). One recent study showed that most Greek parents were nutritionally literate, which was shown to positively influence the feeding patterns of their children (22). Consistent with the present study's findings, one study showed that parents experienced various unpleasant emotions when feeding their children, including anxiety, difficulty, and concern (23). Furthermore, several challenges were encountered by parents when trying to share food literacy skills with their children, including time pressure, safety concerns, lack of interest from children, and conflict between siblings (24). The influence of parents was further demonstrated in a study showing that children reported a higher healthy eating index if their parents had better nutrition literacy (25).

A recent review enlightened the devaluation of food literacy and nutrition literacy topics in MENA countries (6). It found that countries outside MENA boundaries had better food and nutrition literacy status than those within in terms of assessment and food literacy programming (6). Investing in nutrition programs and instructional techniques is necessary to raise a community's food literacy (6). Thus, the current findings emphasize the necessity of provoking serious steps to carry out food literacy interventions parallel to those developed and proven successful in other countries. The OzHarvest's Nutrition Education and Skills Training (NEST) Program has been designed and implemented in Australia to improve adults' food literacy (26). The OzHarvest's NEST Program is a 6-week, 15-h guided public health nutrition program, integrating a series of nutrition activities, goal setting, and practical cooking lessons, utilizing recipes from OzHarvest's Everyday Cookbook and culminating in the sharing of a meal together (26). In the post-intervention period, participants were shown to experience improvements in food security status, cooking confidence, food preparation behaviors, and nutrition knowledge (26). Free of charge, the Food Sensations for Adults (FSA) program is designed to teach people from lower- and middle-income backgrounds about healthy eating and how to shop for and cook nutritious meals (27). Every session is an opportunity to learn something new in a relaxed and supportive setting, and participants are encouraged to try new techniques and foods (27). The FSA program also promoted improved food literacy in 61–74% of adult program participants (low and middle-income Australians), manifested by increased self-reported fruit and vegetable intake, planning, management, selection, and food preparation (27). Similarly, the Food Sensation for Parents (FSP) program assisted parents of children up to 5 years old in promoting healthy family eating habits, introducing solid foods to their children, managing mealtimes and lunchboxes, reading food labels, practicing food safety precautions, budgeting, and meal planning. (28). Parents need to be aware of the worth of parent-child cooking activities, which have been proven to lessen dietary concerns in children, such as picky eating and playing with food and utensils during meals (29). Moreover, children who participated in culinary activities had more varied diets, including more fish, soy products, vegetables, and milk, according to a study based on data from Japan's national nutrition survey on preschool children, a survey of families across the country with toddlers and preschoolers. (29). The importance of parents gaining self-confidence in the kitchen when cooking was highlighted in another cross-sectional study

TABLE 3 The correlates associated with parental food literacy.

Correlates	Parental food literacy				*P*-value
	Adequate (*N* = 997)		Poor (*N* = 848)		
	N	%	*N*	%	
Gender					<0.001**
Female	661	63.9	373	36.1	
Male	336	41.4	475	58.6	
Location					<0.001**
Riyadh	80	45.2	98	54.8	
Makkah	105	62.0	65	33.0	
Madinah	111	67.0	55	33.0	
Eastern province	139	57.5	102	42.5	
Northern borders	0	0.0	53	100.0	
Jawf	53	21.7	192	78.3	
Tabuk	86	66.7	43	33.3	
Ha'il	53	40.0	80	60.0	
Qasim	79	52.7	70	47.3	
Bahah	90	61.3	57	38.7	
Asir	111	88.0	15	12.0	
Najran	89	83.3	18	16.7	
Weight status (n = 1,778)[a]					<0.001**
Underweight	66	76.0	21	24.0	
Normal-weight	334	52.4	304	47.6	
Overweight	284	52.9	253	47.1	
Obese	172	33.4	343	66.6	
Marital status					0.21
Married	838	53.5	728	46.5	
Divorced	52	51.6	49	48.4	
Widowed	107	60.0	71	40.0	
Number of children					0.42
One child	158	57.5	117	42.5	
2–3	188	52.3	171	47.7	
>3	650	53.7	560	46.3	
Education level					<0.001**
Noformal education	54	75.9	17	24.1	
School education level	333	57.1	250	42.9	
University education level	610	51.2	580	48.8	
Job status					<0.001**
Not employed	442	60.8	285	39.2	
Employed (full-time; part-time; and self-employed)	554	49.6	563	50.4	
Monthly income					0.002*
None or less than 3,000 SR	77	50.1	77	49.9	
3,000–25,000 SR	822	53.1	726	46.9	
More than 25,000 SR	98	68.2	46	31.8	
Prevalence of chronic disease(s)					<0.001**
No	630	48.3	674	51.7	
Yes	366	67.8	174	32.2	
Household crowding status					<0.001**
Not crowded	707	63.6	406	36.4	
Crowded	289	39.5	442	60.5	

[a]Some parents did not report their body weight and this is why some data were missing [underweight parents n = 87 (66 were food literate and n = 21 had poor food literacy); normal-weight parents n = 638 (334 were food literate and n = 304 had poor food literacy); overweight parents n = 537 (284 were food literate and n = 253 had poor food literacy); and obese parents n = 515 (172 were food literate and 343 had poor food literacy)].

*Significant at p-value < 0.05 for χ^2 test; **significant at p-value < 0.001 for χ^2 test.

with 657 child-parent pairs from São Paulo, Brazil. This was connected with the children eating less highly processed food (30).

The Kingdom of Saudi Arabia should start considering strategies for improving parents' food literacy, including knowledge of buying groceries, reading nutrition labels, integrating them into nutrition education lessons with their children in school settings, and how to increase their confidence while cooking. Schools are ideal for concurrently educating parents and their children about nutrition (31). School activities might include homework assignments for parents, sending home nutrition educational materials, inviting parents to attend nutrition classes, and inviting parents to present in special events such as School Lunch Week or tasting events (31).

TABLE 4 The determinants of parental food literacy: Binary logistic regression analysis.

Dependent variable: Food literacy [adequate (reference) vs. poor]	AOR (95% CI)	*P*-value
Gender (Reference: Female)	—	—
Male	2.4 (1.9–3.0)	<0.001**
Current location (Residence: Other location)		
Riyadh; Northern borders; Jawf; Ha'il	3.2 (2.6–3.9)	<0.001**
Weight status (Reference: Underweight)	—	—
Overweight or obese	1.6 (1.3–2.1)	<0.001**
Health status (Reference: having no chronic diseases)	—	—
Having chronic disease(s)	0.4 (0.3–0.6)	<0.001**
Education level (Reference: no formal education)	—	—
Educated (school/university)	3.0 (1.6–5.8)	0.001*
Family monthly income (Reference: None or less 3,000 SR)	—	—
3,000–25,000 SR	0.6 (0.4–0.9)	0.02*
More than 25,000 SR	0.3 (0.2–0.6)	<0.001**
Household crowding status (Reference: Not crowded)		
Crowded	1.9 (1.5–2.4)	<0.001**

Variables entered in step 1: age, gender, residence, weight status, education level, job status, monthly income, prevalence of chronic disease, and households' crowding status; AOR, adjusted odds ratio; CI, confidence interval; *significant at p-value < 0.05; **significant at p-value < 0.001.

Nonetheless, formal evaluation and monitoring of the existing food literacy programs must be conducted to determine the degree of implementation and whether they are appropriate in the Saudi Arabian context.

4.2. Parental involvement in adolescents' eating habits

Children develop their eating habits primarily from their parents, both genetically and in terms of the setting in which they are raised. One study showed that adolescents' diet quality scores positively correlate with their perceptions of their parents' attitudes toward nutrition, their peers' dietary habits, and caregivers' assessments of parental surveillance of adolescent dietary behavior (32). They reported that parental support and close food choice monitoring had resulted in higher-quality diets (32). Meanwhile, 20.5% of adolescents reported a lack of parental rules on eating, such as breakfast not being mandatory, meals in front of the TV being allowed, and not restricting sweets and soft drinks, had resulted in lower-quality diets (32). Teenagers who did not adhere to their parents' dietary guidelines were more likely to miss breakfast, consume fewer fruits and vegetables, and consume sweets, soft drinks, and energy drinks often (33). Trends like an increase in eating occasions, portion sizes, energy density, snacking frequency, skipping breakfast, and eating meals away from home can negatively affect the diet quality and energy balance of children and adolescents. (33). Intriguingly, it has been established that helping with family meal preparation improves adolescents' food quality and eating behaviors (33). Programs or interventions that teach cooking skills to adolescents could be good initiatives to improve their nutrition status; of these programs are OzHarvest's primary-school Food Education and Sustainability Training (FEAST) program (34), Food Sensation for Schools (FSS) (35), Fuel Your Future (FYF) (36), Teens CAN: Comprehensive Food Literacy in Cooking, Agriculture, and Nutrition (37), Cook IT UP (38), and Food Literacy Project's Youth Community Agriculture Program (YCAP) (39). Ensuring adequate parental food literacy could positively impact everyone in the community by improving the health and nutritional status of the parents and their children.

4.3. The correlates of parental food literacy

A person's ability to maintain a healthy diet is influenced by various factors, including socioeconomic status, cultural norms, and level of nutritional literacy (40). This study's findings reveal that parental gender, residence, weight status, health status, job status, education level, monthly family income, and household crowding status contributed most significantly to determining parents' food literacy status. They align with the results of other research that assessed gender, income, health, and weight status in the adult population (21, 41, 42). Similar conclusions were drawn from studies involving children and adolescents, which also discovered correlations between the participants' socio-demographic characteristics and food literacy (43, 44). The current study showed that fathers were 2.4 times more likely than mothers to be food illiterate. This finding is warrantable and not unpredicted, as in Arab cultures, mothers are more involved in cooking and shopping activities than fathers. In addition, the literature showed that up to 50% of gender differences in food preferences might be explained by health attitudes and motivations to lose weight (45). This could account for the current study's higher level of food literacy among women. Additionally, these findings corroborated data from a recent study showing that women paid more attention to nutritional properties than men and obtained higher food literacy scores (46).

Parents who are overweight or obese showed an increased risk of being food illiterate by 60%. This conclusion could be explained by the fact that people with low food literacy are more likely to engage in high-risk eating behaviors that lead to weight gain. Risky eating habits contributing to weight gain include a diet high in fast food, skipping meals, and consuming a disproportionate number of processed foods (47). Compared to

those with chronic disease(s), healthy participants had a 60.0% higher probability of expressing poor food literacy in the current study; this link may be due to parents dealing with chronic disorders needing to consult doctors and dietitians more often. Additionally, they may be more interested in learning about nutrition and food from various sources, such as the nutritional value of foods, how to cook a healthy meal, and how nutrition may be utilized to control non-communicable diseases (42).

The current study indicated an unexpectedly high probability of food illiteracy among educated parents. This result was unusual, but it is reasonable given that various confounding factors influence parental food literacy in addition to education level (6). Habits, label reading, consumption patterns, academic success, availability of healthy foods, variety in the diet, and nutrient sufficiency were all potential confounding variables (6). Despite the scarcity of research in this field, the findings of this study were comparable with those of a Turkish study, which revealed that participants' food literacy scores decreased in proportion to their academic ranks (42). These results might be explained by knowing that educated individuals are more likely to be employed, leading to a busy lifestyle in which many people struggle to find the time to make nutritious meals and pay attention to nutritional information (48). Busy family lives were connected with a greater likelihood of parents giving their children fast food (48). Previous research suggested that parents appeared to be aware of the need to feed their children nutritious meals and snacks. Still, parents were concerned they would become distracted throughout the day owing to their demanding work schedules, leading them to drive by fast food restaurants to feed their children for a quick meal (49). However, more research is needed to investigate these findings thoroughly.

When the food literacy scores of the participants were assessed according to their residential regions, it was discovered that parents from the provinces of Riyadh, Northern borders, Jawf, and Ha'il had a threefold risk of being food illiterate compared with parents from other provinces. Since this is the first study of its kind in Saudi Arabia, more research is needed to understand the results fully. This is especially true given the impossibility of initiating a comprehensive description of the areas where participants had a good level of food literacy. While some of these regions are rural, others are metropolitan and central. However, this finding may help target future food literacy programs to prioritize vulnerable populations for intervention in Saudi Arabia. Lower monthly income and crowded households also predicted worse food literacy scores among parents. This might be related to food illiteracy being frequently associated with a household's food security status (27). Food-insecure people, especially those with low monthly incomes, do not usually focus on their diet quality (a utility pillar of food security). Food insecurity and food literacy thus have a dual relationship (27).

4.4. Limits and strengths

The study's cross-sectional design allows for drawing associations but not causal relationships. Information bias and misreporting could be assumed as the questionnaire was online-based and self-administered. Furthermore, this study did not adequately present households lacking internet access, and data on the households' diet quality were not collected. On the other hand, public health improvements necessitate research on essential elements, such as the level of food literacy in healthy eating. Therefore, despite the above limitations, the findings of this study are expected to fill research gaps in food literacy and contribute to existing scholarship in this area. In addition, this is the first study of its kind to examine the relationship between parental food literacy and other variables in Saudi Arabia. The large and diverse sample also allows us to acquire a more accurate depiction of the level of food literacy among parents in the kingdom of Saudi Arabia. The sample's representativeness of the relevant population facilitates a more realistic view of parents' food literacy in Saudi Arabia.

5. Conclusion and future perspectives

This study is the first to provide data on food literacy status among Saudi parents. Its findings reveal that nearly half of the Saudi parents sampled had poor food literacy. Parental gender, residence, weight status, health status, job status, education level, monthly income, and household crowding status contributed most significantly to predicting parental food literacy. Parents are the essential first teachers for their children; therefore, food illiteracy could negatively affect the nutritional outcomes of the whole family. The current study findings should be employed in future programming and policy-making approaches to reach Saudi parents for necessary food literacy interventions. These interventions could bolster their confidence in cooking and knowledge of how to buy groceries, read nutrition labels, and provide nutrition education lessons for their children. Intervention suggestions are context-specific and should be evaluated for their applicability and effectiveness, considering the nutrition vulnerabilities of every population group. In closing, programs to address food literacy in parents are indispensable in Saudi Arabia, and policymakers should prioritize them in their agendas.

Data availability statement

The datasets presented in this study are not readily available due to confidentiality reasons, requests to access the data can be directed to the author KB, kbookari@taibahu.edu.sa.

Ethics statement

The studies involving human participants were reviewed and approved by Taibah University, Saudi Arabia. The patients/participants provided their written informed consent to participate in this study.

Author contributions

KB conceived the study, conducted the analyses, interpreted the results, wrote the manuscript, critically reviewed the manuscript, and approved the final version submitted for publication.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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What is the level of nutrition literacy of Saudi adolescents? A national wide exploratory cross-sectional study

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Background: Despite being a prolific research topic, studies evaluating nutrition literacy in the Arab world are scant and still nonexistent in the Kingdom of Saudi Arabia. Therefore, a national study was launched with the aim to (1) assess nutrition literacy among Saudi adolescents aged 10–19 years old and (2) determine its correlates.

Methods: A cross-sectional study was launched across all Saudi provinces between 29 April and 6 June 2022, enrolling a convenience sample of 2,115 adolescents (mean age = 16.8 ± 2.5; girls: 48.7%). An online self-administered questionnaire was disseminated to eligible participants to collect relevant data.

Results: Study findings showed that nearly half of the adolescents (44.6%) had poor nutrition literacy. The male gender doubled the risk of adolescents having poor nutrition literacy (OR = 2.0, CI = 1.5-2.5, $p < 0.001$). Northern border residents were 14 times more likely to be nutritionally illiterate, in contrast to adolescents residing in Riyadh (OR = 14.0, CI = 7.3–28.0, $p < 0.001$). Adolescents were more likely to be nutritionally illiterate if they were underweight or overweight (OR = 2.7, CI = 1.6–4.7, $p < 0.001$; OR = 2.2, CI = 1.7–2.9, $p < 0.001$). School students had 2 times more risk of having poor nutrition literacy, in contrast to those who were enrolled in universities (OR = 1.8, CI = 1.4–2.4, $p < 0.001$). Nutrition illiteracy was 4 times higher among adolescents having caregivers else than their parents (OR = 3.9, CI = 2.2–6.9, $p < 0.001$). Parental education level also contributed to determining adolescents' nutrition literacy status.

Conclusions: It has become essential to courage the development of supportive school environments in Saudi Arabia to promote nutrition education and improve adolescents' nutrition literacy. Without a doubt, this calls for taking a holistic approach on the part of education and health ministries, nutrition professionals, educators, parents, and, most importantly, the teenagers themselves, who must have the desire and motivation to learn.

KEYWORDS

nutrition literacy, Arab world, kingdom of Saudi Arabia, Saudi, adolescents

1. Introduction

Research debates on nutrition literacy topics have been receiving prominence over the years. Nutrition literacy extends beyond just people reading about nutrition; it also includes numeracy and cognitive abilities that shape healthy food selections and eating behaviors (1). Nutrition literacy is "the degree to which people have the ability to obtain, process and understand basic diet information, as well as the tools needed to make appropriate nutrition decisions" (2). Adequate nutrition literacy requires an individual not only to read well but also to understand health and nutrition concepts and to have basic quantitative skills (defined as numeracy: "the ability to use and understand numbers in daily life, including the ability to read and interpret nutrition information" (3). People without these skills may have difficulty understanding concepts of healthful diets, reading nutrition information, and measuring portion size (3). Functional nutrition literacy (FNL), interactive nutrition literacy (INL), and critical nutrition literacy (CNL) are the three nutrition literacy levels that have been identified over time. FNL stands for functional numeracy literacy, or the ability to apply basic literacy abilities, such as reading and comprehending food labels and understanding the fundamentals of dietary guidelines. INL includes more sophisticated literacy abilities, such as the capacity to communicate effectively with nutrition counselors on a cognitive and interpersonal level, as well as a desire to find and use accurate nutrition information to change one's eating habits and behavior. CNL refers to the ability to analyze nutrition information and recommendations critically as well as the willingness to take part in initiatives to eliminate nutritional barriers from a personal, social, and global perspective (4). It has been noticed that people and communities with higher nutrition literacy are able to comprehend nutrition information and, as a result, adhere to a healthy diet. Since they are more knowledgeable about the relationship between a poor diet and disease, nutrition literacy can help lower the disease burden and lessen economic and health disparities in underprivileged areas (5). Improper eating habits are one of the reasons that worldwide public wellness is approaching a tipping point. One attempt is made to improve a poor diet through nutrition literacy programs (6). Nutrition literacy is growing in importance in the management, treatment, and prevention of non-communicable diseases (NCDs) (7). This is particularly important given that every year, NCDs cause the deaths of 41 million people worldwide (8). As food preferences and eating habits are founded early in life, children and adolescents must equip adequate nutrition literacy levels to guide appropriate eating behaviors (9). The initiative to promote nutritional literacy is an active endeavor to educate the general population, and adolescents in particular, on the value of health. Nutrition literacy programs are focused on the effort to learn more about healthy lifestyle, understand the motivations for choosing to live a healthy lifestyle, take an active role in helping others, and critique the sources of food consumed (10).

Adolescence, according to the World Health Organization (WHO), is the period between the ages of 10 and 19. Adolescents are a transitional population, sharing some nutrition-related issues with children and some with adults (11). Adolescence is the stage of life during which, after infancy, growth occurs at the fastest rate, being oversensitive to nutrition deficiencies (12). Adolescent nutrition is critical for compensating for childhood deficiencies and should include nutrients required to meet the demands of physical and cognitive growth and development, provide adequate stores of energy for illnesses and pregnancy, and prevent adults onset of nutrition-related diseases (11). Additionally, adolescents desire to grow self-reliant and forge their identity in all aspects, including their food choices and eating habits. And hence, nutrition illiteracy might cause adolescents to shoulder poor nutrition outcomes and health vulnerabilities when undesirable choices occur (13). Nutrition literacy had been frequently linked to eating behaviors, dietary diversity, nutrient adequacy, food label use, and school performance among multiple demographics, particularly adolescents (14–18).

There are 1.3 billion adolescents worldwide as of today, making up 16% of the world's population (19). Saudi Arabia, like other nations, is witnessing a youth revival, with 20% of its population being adolescents between the ages of 10 and 19 (20). Furthermore, it was estimated that, by 2030, Saudi Arabia will have a 12% increase in the school-age population (21). Effective public health initiatives like children's immunizations and healthcare providers have generally been successful in Saudi Arabia in reducing the burden of communicable diseases and infant mortality, respectively. Non-communicable diseases (NCDs) largely account for the current disease burden; hence adult-specific NCDs have taken center stage on the healthcare and health research agendas. The key modifiable risk factors, such as tobacco use, excessive alcohol use, unhealthy diets, and insufficient physical activity, start much earlier in life during adolescence, so the emphasis should be on the adolescent period and prevention of these risk factors as well as promotion of protective factors (11). Late adolescents and youth are preparing to or have recently experienced independent living as they go from adolescence to adulthood. As a result, adolescents are often given additional responsibilities for organizing, choosing, and cooking meals than younger generation. Because of this, the level of knowledge and skills that this age group has regarding food and nutrition may be able to assist them in navigating the complex and multifaceted factors influencing their dietary practices, which may have a significant impact on their eating patterns and health in the future (22).

Adolescents' poor eating habits in Saudi Arabia are a major public health concern, and during the COVID-19 restriction period, these unhealthy habits were made worse (11). In 2021,

nearly 24 and 41% of Saudi male and female adolescents were obese, respectively (23). Rapid urbanization and lifestyle changes brought about by Saudi Arabia's flourishing economy have contributed substantially to sedentary behavior, western patterns of diets, and the country's rising rates of overweight and obesity (24). Obesity among Saudi adolescents was also observed to be linked to unfavorable eating habits, including daily consumption of soft drinks (25). Along these, unhealthy dietary patterns were reported among Saudi adolescents; manifested by fast food consumption, skipping breakfast, and low fruit and vegetable consumption (26). Adolescents are thought to be the predominant consumers of fast food. The extensive availability and ubiquity of fast-food restaurants, the taste preferences, the comparatively low cost of large serving sizes, and convenience; all contribute to this. A previous study in Saudi Arabia showed that 85% of adolescent participants preferred fast food to home cooking (27). Despite these facts, researchers and decision-makers in the discipline of nutrition typically concentrate on children, women, and the elderly, overlooking the "neglected" adolescents (28).

The majority of the interventions, so far, have either been directed toward pregnant women or, to a minor extent, lactating women or children aged 0 to 5 years. Adolescents haven't yet, however, received much attention from nutrition-related programs. Adolescent-specific programs are severely lacking in the Arab region. Lack of age and sex-disaggregated data on the health and nutritional status of adolescents at the national level is one of the main underlying causes of the absence of policies and programs for improving their health and nutritional status. Adolescents are often neglected in public health initiatives due to a lack of qualified healthcare professionals and facilities that can cater to their unique demands (11). According to the available evidence, no studies have so far been done to assess nutrition literacy among Saudi adolescents. This, coupled with the most recent review's warning on the need to address the nutrition literacy topic in the Arab region (28), motivates us to conduct the current study. Therefore, the author launched this national study to be the first of the region's kind to (1) assess nutrition literacy among Saudi adolescents aged 10–19 years old and (2) determine its correlates.

2. Methods and materials

2.1. Study design and participants' recruitment

This study followed a cross-sectional design and the convenience snowballing method. It was launched between 29 April and 6 June 2022. An online-based self-administered questionnaire consisting of multiple parts was disseminated to eligible participants to meet the study aims. To increase the sample representation and generalizability of the results, adolescents were recruited from almost all of Saudi Arabia's provinces: Riyadh, Makkah, Madinah, Eastern province, Northern borders, Jawf, Tabuk, Ha'il, Qasim, Bahah, Asir, and Najran. The research team attempted to advertise the study on different social media platforms with the aid of the author's academic networks and scholarly connections. To encourage participation, participants and their guardians were informed that this study is intended to be the first stepping stone forward in actively advocating for nutrition education in Saudi Arabian schools. Overall, in this study, the author enrolled a total convenient sample of 2,115 adolescents aged 10–19 years old.

2.2. Adolescents' eligibility

The adolescent should be 10–19 years old and have Saudi nationality to be regarded for inclusion. This age range was determined based on the WHO's claim that the adolescence stage is a life period ranging from 10–19 years old (29). Additionally, to ensure a more diverse sample for this study, one adolescent child per household was enrolled.

2.3. Covariates

2.3.1. Demographic information

As designed by nutrition experts, the questionnaire contains the following inquiries to cover the adolescents' demographic characteristics in relevance to the study aims: age, gender, current residency, education level, maternal education level, paternal education level, adolescents' working status, and the primary caregiver(s) (mother, father, other caregivers, and living alone). Adolescents were asked to self-report their body weight and height; consequently, adolescents were classified as being underweight, normal-weight, overweight, or obese per the WHO criteria on body weight classification (30).

2.3.2. Nutrition education in school settings

In line with the study objectives, adolescents were asked if they typically receive nutrition education in their schools' curriculum, with the type of school they were enrolled in (public school, private school). The adolescents had the option of a binary response (Yes, I receive nutrition education in my school; No, I don't). This could give insights into the urge of starting intervening in adolescents' nutrition knowledge and skills in school settings.

2.4. Outcome variable: Nutrition literacy

To assess adolescents' nutrition literacy (total nutrition literacy: TNL), the author used the valid 22-items Adolescent

TABLE 1 The adolescent nutrition literacy scale (ANLS).

Question	Dimension	Min-Max score
1. I find that the language used by nutrition, health and food experts is difficult to be understood.	Functional Nutrition Literacy (FNL)	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
2. I find it difficult to understand the jargon (technical words) used by nutrition, health and food experts	FNL	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
3. When I read information about nutrition, food, or diet, I find it difficult to understand	FNL	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
4. I find it difficult to know how I should change my diet when I get dietary advice from the doctor, nurse or the like	FNL	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
5. When I read information about nutrition food or diet, I need someone to help me understand it.	FNL	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
6. I am not familiar with World Health Organization (WHO) recommendations for daily intake of fruits and vegetables.	FNL	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
7. When I read an article about nutrition, food, or diet, I find words that I don't know	FNL	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
8. I have gathered information about diet from various sources that I think is relevant for me.	Interactive Nutrition Literacy (INL)	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
9. I use the internet when I am looking for information about nutrition such as diet.	INL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
10. I discuss about diet with my friends, family and relatives	INL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
11. I have changed my eating habits based on the information about diet that I have gathered.	INL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
12. I often read material about what constitutes a balanced diet	INL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
13. I readily take the initiative to discuss with dietary experts (for example a doctor, nurse or the like) about healthy eating	INL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
14. I would readily get involved in political issues targeted at improving people's diet.	Critical Nutrition Literacy (CNL)	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
15. I am willing to take an active role in measures aimed at promoting a healthier diet at my school.	CNL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
16. I expect my school to serve healthy food.	CNL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
17. I try to influence others (for example my family and friends) to eat healthy food.	CNL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
18. It is important for me that the school canteens have a good selection of healthy food.	CNL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)
19. I tend to be influenced by the dietary advice I read in newspapers, magazines or elsewhere	CNL	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
20. I tend to be influenced by the dietary advice I get from my family, friends.	CNL	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
21. I believe that the media's presentation of scientific findings about nutrition, diet, food is correct.	CNL	Strongly disagree = 5 (max score) to Strongly agree = 1 (min score) (reverse-coded question)
22. When I read information about nutrition, diet or food it is important to me that it is based on scientific evidence.	CNL	Strongly agree = 5 (max score) to strongly disagree = 1 (min score)

Nutrition Literacy Scale (ANLS) (31) (Refer to Table 1). ANLS evaluated three components of TNL: Functional NL (FNL) (7 questions), Interactive NL (INL) (6 questions), and Critical NL (CNL) (9 questions). FNL reflects the capacity to understand nutrition information. INL refers to the communication and interactive skills required to attain nutrition information. CNL reflects the ability to critically evaluate nutrition information (4). Each question in the ANLS has a score ranging from 1 to 5 (5-points Likert scale: strongly disagree to strongly agree). A higher score indicates better NL. The questionnaire has an overall score range from 22 to 110. The median scores, or second quartiles, of the study participants were used to determine the cutoffs. The adolescents were classified as having adequate or poor nutrition literacy based on the observed median scores, which were 67.0, 24.0, 17.0, and 28.0, respectively, for the TNL, FNL, INL, and CNL. Thus, an overall score of less than 67.0 indicated poor nutrition literacy, and a score of 67.0 and above (over 110) was an indication of adequate nutrition literacy among adolescents in this study (31).

The used questionnaire underwent a face validity (or "logic validity") review to confirm its accuracy. Each survey question was evaluated independently by an expert panel constituted of a public health nutritionist and four registered dietitians. To assure that it included crucial elements of nutrition literacy, such as the capacity to perform fundamental tasks, interact with others, and form sound judgments, the questionnaire was double-checked. A statistician (an APD and an authority in question design) reviewed the survey for common errors (e.g., leading, confusing, or double-barreled questions). First, the study's pilot respondents were two researchers (Nutritionists) from Taibah University's Department of Applied Medical Science (TU). Then ten adolescents between the ages of 10 and 19.

2.5. Ethical approval of the study protocol

The ethical committee at Taibah University, Saudi Arabia, approved the current study protocol while adhering to the guidelines laid down in the Helsinki Declaration at all study stages. The study participants provided their informed consent electronically before filling out the online survey. For adolescent participants, parents or official caregivers need to give consent for the adolescent to participate in the study. To start participating in filling out the questionnaire, consent is required from both parents/guardians and the adolescent. If any of the parties, whether parents/guardians or adolescents themselves, do not agree, the questionnaire will be terminated immediately. The participation was voluntary with no penalty for refusal or withdrawal.

2.6. Statistical analysis

The author performed the statistical analysis using the Statistical Package of Social Sciences Software (SPSS) (Version 25.0. IBM Corp: Armonk, NY, USA). A "weighting" variable was created to enhance the representation of the study sample according to adolescents' gender and residency. Respondents' characteristics were presented as frequencies (percentages) for categorical variables, while means ± standard deviation (SD) for continuous variables. The adolescence stages were classified per the WHO criteria (24): early adolescence (10–13 years old), middle adolescence (14–16 years old), and late adolescence (17–19 years old). Continuous variables' normal distribution was checked using the Shapiro-Wilk test. The Mann-Whitney *U* test was used to detect mean differences between study variables composed of two groups (such as gender). Chi-squared test ($\chi 2$) was used to determine associations between study variables (the covariates, and the outcome variable: nutrition literacy). In addition, the backward stepwise method of binary logistic regression was used to identify the determinants of adolescents' nutrition literacy. A p-value of 0.05 and below was considered significant for all analytical tests.

3. Results

3.1. Demographic characteristics of adolescents

A total of 2,115 Saudi adolescents were included in this study and their data were considered for analysis. Among all adolescents, 48.7% were girls. The mean age ± SD of the overall sample was 16.8 ± 2.5, in which male adolescents were younger (16.0 ± 3.0) than their female counterparts (17.0 ± 2.0), $p < 0.001$. When stratified per their age, the majority of the adolescents (70.3%) were in their late adolescence stage (17–19 years old), whereas the remaining (29.7%) were young (10–13 years old) or middle-aged (14–16 years old) adolescents. Adolescents were recruited from almost all Saudi provinces per the following distribution: Riyadh (8.1%), Makkah (8.6%), Madinah (7.8%), Eastern province (10.7%), Northern borders (14.6%), Jawf (5.1%), Tabuk (6.7%), Ha'il (6.3%), Qasim (6.0%), Bahah (8.2%), Asir (9.0%), and Najran (8.9%). Furthermore, 38.6% of the adolescents were overweight or obese. Regarding their education level, just 0.5% of the adolescents had no formal education, while the remaining were either attending schools (59.7%) or universities (39.7%). As for their parents' highest education level, 85% of the mothers had a school or university education level, compared to 92.0% of the fathers. Most adolescents (68.8%) reported having both parents as primary caregivers. Furthermore, around one-quarter (23.0%) of the adolescents were working (Table 2).

TABLE 2 Demographic, general characteristics and the BMI of adolescents.

Variables	Overall ($N = 2,115$)		Girls ($n = 1,030$)		Boys ($n = 1,085$)		p-value
	N	%	*n*	%	*n*	%	
Adolescence stage							<0.001*
Early adolescence (10–13 years old)	320	15.1	52	5.0	268	24.7	
Middle adolescence (14–16 years old)	308	14.6	230	22.3	79	7.3	
Late adolescence (17–19 years old)	1487	70.3	748	72.7	738	68.0	
Current residency							<0.001*
Riyadh	171	8.1	83	8.0	88	8.1	
Makkah	182	8.6	78	7.6	103	9.5	
Madinah	165	7.8	85	8.3	79	7.3	
Eastern Province	226	10.7	62	6.0	164	15.1	
Northern borders	309	14.6	27	2.6	283	26.0	
Jawf	107	5.1	107	10.4	0	0.0	
Tabuk	142	6.7	97	9.5	44	4.1	
Ha'il	134	6.3	134	13.0	0	0.0	
Qasim	126	6.0	99	9.6	27	2.5	
Bahah	174	8.2	80	7.8	94	8.7	
Asir	191	9.0	84	8.1	108	9.9	
Najran	188	8.9	94	9.1	94	8.7	
Weight status							<0.001*
Underweight	69	3.3	27	2.6	42	3.9	
Normal-weight	1,229	58.1	801	77.8	429	39.5	
Overweight	810	38.3	196	19.0	614	56.5	
Obese	7	0.3	5	0.5	2	0.1	
Adolescent's education level							<0.001*
Not attending school	11	0.5	10	0.9	1	0.2	
Elementary school level	275	13.0	33	3.2	243	22.4	
Intermediate school level	411	19.4	155	15.1	256	23.6	
Secondary school level	578	27.3	350	34.0	228	21.0	
University level	840	39.7	482	46.8	357	32.9	
Maternal education level							<0.001*
Illiterate	318	15.0	172	16.7	146	13.4	
Elementary school level	192	9.1	84	8.2	108	10.0	
Intermediate school level	546	25.8	224	21.8	322	29.6	
Secondary school level	276	13.1	153	14.8	123	11.3	
University level	783	37.0	397	38.5	386	35.6	
Paternal education level							<0.001*
Illiterate	168	8.0	54	5.3	114	10.5	
Elementary school level	187	8.9	65	6.3	122	11.3	

(Continued)

TABLE 2 (Continued)

Variables	Overall ($N = 2,115$)		Girls ($n = 1,030$)		Boys ($n = 1,085$)		p-value
	N	%	*n*	%	*n*	%	
Intermediate school level	305	14.4	63	6.1	242	22.3	
Secondary school level	507	24.0	334	32.4	173	15.9	
University level	948	44.8	514	49.9	434	40.0	
Primary caregiver							<0.001*
Both parents	1456	68.8	786	76.3	670	61.7	
The father	59	2.8	18	1.8	41	3.8	
The mother	380	18.0	138	13.4	242	22.3	
Others	160	7.6	29	2.8	131	12.1	
None (living alone)	60	2.8	59	5.7	1	0.1	
Currently working							<0.001*
No	1,630	77.1	936	90.9	694	64.0	
Yes	485	22.9	94	9.1	391	36.0	

*Significant at p-value < 0.001 for $\chi 2$ test.

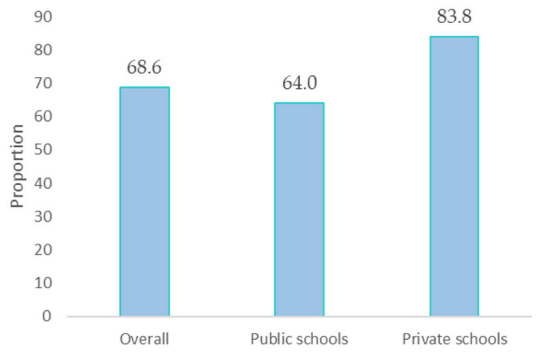

FIGURE 1
The proportion of adolescents not receiving nutrition education in school's curriculum.

3.2. Nutrition education in Saudi school settings

The author asked school students ($n = 1,264$) to report the school type they were attending and whether they receive nutrition education in their school's curriculum. Overall, 68.6% of the students were not receiving nutrition classes in their schools, particularly those studying at private schools (83.8%), in contrast to their counterparts enrolled in public schools (64.0%), $p < 0.001$ (Figure 1).

3.3. Adolescents' nutrition literacy status

Overall, around 45.0% of adolescents were observed to have inadequate nutrition literacy levels (TNL). As per its components, 44.2% had functional nutrition illiteracy, 45.3% had inadequate INL, and 41.8% had poor scores in CNL. More boys than girls had poor TNL (60.6 vs. 27.8%), INL (56.3 vs. 33.8%), and CNL (49.0 vs. 34.2%), all p-values < 0.001 (Table 3).

3.4. The correlations associated with the adolescents' nutrition literacy status

Table 4 displays the relationships between study variables and adolescents' nutrition literacy. Considering adolescents' age, young adolescents had mostly poor nutrition literacy (53.9%), which exceeds the prevalence reported among middle-aged (48.2%) and older adolescents (41.9%), $p < 0.001$. Nutrition illiteracy was observed among 6 out of 10 boys, in contrast to 27.8% of girls, $p < 0.001$. Accounting for their residence, poor nutrition literacy scores were prevalent the most among the Northern province residents (91.4%), exceeding that reported among all other provinces, $p < 0.001$. Of relevance, more than half (60.1%) of overweight and underweight adolescents were nutritionally illiterate, $p < 0.001$ (Table 4).

On the other hand, school students had the highest prevalence of low nutrition literacy scores (52.5% of them), exceeding that reported among university students (33.1%), $p < 0.001$. Similarly, more than half of fathers with school

TABLE 3 The status of adolescents' nutrition literacy, overall and by adolescents' gender.

	Overall ($N = 2,115$)		Girls ($n = 1,030$)		Boys ($n = 1,085$)		p-value
	N	%	*N*	%	*N*	%	
TNL[a]							<0.001*
Poor	944	44.6	286	27.8	658	60.6	
Adequate	1,171	55.4	744	72.2	427	39.4	
FNL[b]							0.07
Poor	934	44.2	434	42.2	500	46.1	
Adequate	1,181	55.8	596	57.8	585	53.9	
INL[c]							<0.001*
Poor	959	45.3	348	33.8	611	56.3	
Adequate	1,156	54.7	682	66.2	474	43.7	
CNL[d]							<0.001*
Poor	884	41.8	352	34.2	531	49.0	
Adequate	1,231	58.2	678	65.8	554		

[a]Total Nutrition Literacy; [b]Functional Nutrition Literacy; [c]Interactive Nutrition Literacy; [d]Critical Nutrition Literacy; *significant at p-value < 0.001 for $\chi 2$ test.

(53.9%) or university (52.3%) education levels had adolescent children who were nutritionally literate, with p-value < 0.001. However, 52.4% of mothers with a university education level had nutritionally illiterate adolescent children, $p < 0.001$. Additionally, it was observed that adolescents having either parent (mother or father) as a primary caregiver or other caregivers (grandfather, grandmother, other relatives, etc…) had poorer nutrition literacy (59.0 and 77.1% of them, respectively). Likewise, 56.6% of working adolescents were nutritionally illiterate, as opposed to 41.0% of non-workers. Public school students were more nutritionally illiterate than those enrolled in private schools (45.1 vs. 27.5%), $p < 0.001$. Also, 52.2% of adolescents not receiving nutrition education at school had low nutrition literacy scores, compared to 53.1% of adolescents who reported receiving nutrition education in their schools' curriculum, $p < 0.001$ (Table 4).

3.5. The determinants of adolescents' nutrition literacy: The binary logistic regression analysis

Based on the bivariate analysis shown above, the author attempted to identify the most significant determinants predicting the adolescents' nutrition literacy status using the backward stepwise method of the binary logistic regression. Table 5 shows that male adolescents, compared to females, were 2 times more likely to have poor nutrition literacy scores (OR = 2.0, CI = 1.5–2.5, $p < 0.001$). Northern border residents were 14 times more probable to be nutritionally illiterate, in contrast to adolescents residing in Riyadh (OR = 14.0, CI = 7.3–28.0, $p < 0.001$). As for weight status, being underweight increased the chance of having poor nutrition scores among adolescents by 3 times (OR = 2.7, CI = 1.6–4.7, $p < 0.001$). As well, overweight adolescents had 2 times more likelihood of being nutritionally illiterate (OR = 2.2, CI = 1.7–2.9, $p < 0.001$).

School students had double the risk of having poor nutrition literacy, in contrast to those who were enrolled in universities (OR = 1.8, CI = 1.4–2.4, $p < 0.001$). Mothers with lower education level (school level or illiterate) had 60.0 and 10.0% lower probability to have nutrition illiterate adolescents, respectively, $p < 0.001$. respectively. On the other hand, non-educated fathers had 2.4 times more probability of having nutritionally illiterate adolescent children (OR = 2.4, CI = 1.1–5.0, $p = 0.02$). As well, adolescents having caregivers else than their parents were 4 times more susceptible to having poor nutrition literacy scores (OR = 3.9, CI = 2.2–6.9, $p < 0.001$) (Table 5).

4. Discussion

This cross-sectional study assessed the adolescents' nutrition literacy and its determinants in a large population-based sample. To the best of author's knowledge, it is the first of its kind at the national level, which is significant given the importance of improving nutrition literacy among adolescents in light of rising obesity levels. This study enrolled a convenience sample of 2,115 adolescents aged 10–19 years old and recruited from almost all Saudi provinces. Around 59.7% of the sampled adolescents were school students, with 76.8% enrolled in public schools. Of them,

TABLE 4 The correlations associated with the adolescents' nutrition literacy status.

Correlates	Nutrition literacy		*p*-value
	Poor $N = 944$	Adequate $N = 1,171$	
	N (%)	*N* (%)	
Adolescence stage			<0.001 *
Early adolescence (10–13 years old)	172 (53.9)	147 (46.1)	
Middle adolescence (14–16 years old)	149 (48.2)	160 (51.8)	
Late adolescence (17–19 years old)	623 (41.9)	864 (58.1)	
Gender			<0.001*
Female	286 (27.8)	744(72.2)	
Male	658 (60.6)	428 (39.4)	
Residency			<0.001*
Riyadh	77 (45.3)	93 (54.7)	
Makkah	70 (38.8)	111 (61.2)	
Madinah	72 (43.6)	93 (56.4)	
Eastern Province	120 (52.5)	106 (47.5)	
Northern Province	283 (91.4)	27 (8.6)	
Jawf	53 (50.0)	53 (50.0)	
Tabuk	44 (31.2)	98 (68.8)	
Ha'il	0 (0.0)	134 (100.0)	
Qasim	48 (38.0)	78 (62.0)	
Bahah	45 (25.5)	130 (74.5)	
Asir	38 (19.9)	154 (80.1)	
Najran	94 (50.2)	94 (49.8)	
Weight status			<0.001*
Underweight	41 (60.1)	27 (39.9)	
Normal weight	414 (33.7)	816 (66.3)	
Overweight	487 (60.1)	323 (39.9)	
Obese	2 (27.6)	5 (72.4)	
Adolescents' education level			<0.001*
Not attending school	2 (19.4)	9 (80.6)	
School level	664 (52.5)	601 (47.5)	
University level	278 (33.1)	562 (66.9)	
Maternal education level			<0.001*
Never attend school	41 (13.1)	276 (86.9)	
School level	462 (48.5)	523 (51.5)	
University level	411 (52.4)	372 (47.6)	
Paternal education level			<0.001*
Never attend school	32 (18.8)	137 (81.2)	
School level	460 (46.1)	538 (53.9)	
University level	452 (47.7)	496 (52.3)	
Primary caregiver			<0.001*
Both parents	561 (38.5)	896 (61.5)	
Either parent	259 (59.0)	180 (41.0)	
Others	123 (77.1)	37 (22.9)	
None (living alone)	1 (1.3)	59 (98.7)	
Currently working			<0.001*
No	669 (41.0)	961 (59.0)	
Yes	274 (56.6)	210 (43.4)	
School type			<0.001*
Public	382 (45.1)	589 (46.4)	
Private	233 (27.5)	60 (4.8)	
Receiving nutrition education in schools' curriculum			<0.001*
No	453 (52.2)	415 (47.8)	
Yes	211 (53.1)	186 (46.9)	

*Significant at p-value < 0.001 for $\chi 2$ test.

68.6% were not receiving nutrition education in their schools' curriculum. Study findings showed that nearly half of the adolescents (44.6%) had poor nutrition literacy. Moreover, their nutrition literacy status was associated with adolescents' gender, residency, education level, weight status, primary caregiver, and maternal and paternal education level as well.

The overall scarcity of studies on nutrition literacy topic makes it a challenge to compare the results of the present study to those of national or regional studies. Recent review research has shown that only three MENA countries—Lebanon, Palestine, and Iran—have discussed nutrition literacy. The review emphasized that people in these nations typically had inadequate nutrition literacy levels. The findings of the current study are comparable to those reported among Lebanese, Palestinian, and Iranian adolescents, in which 44.6% of Saudi Arabian adolescents were found to be nutritionally illiterate (28). Additionally, findings of this study are similar to that reported among Turkish adolescents where a considerable proportion of them had inadequate nutrition literacy levels (32, 33). As well,

TABLE 5 The determinants of adolescents' nutrition literacy: The backward stepwise method of the binary logistic regression.

Binary logistic regression taking the nutrition literacy (TNL) [Poor (reference) vs. Adequate] as the dependent variable	AOR (95% CI)	*p*-valve
Gender (Reference: Girls)	-	-
Boys	2.0 (1.5–2.5)	<0.001**
Residence (Reference: Riyadh)		
Makkah	0.6 (0.4–0.9)	0.02*
Northern borders	14.0 (7.3–28.0)	<0.001**
Asir	0.5 (0.1–0.4)	<0.003*
Najran	0.2 (0.1–0.4)	<0.001**
Weight status (Reference: Normal weight)	-	-
Underweight	2.7 (1.6–4.7)	<0.001**
Overweight	2.2 (1.7–2.9)	<0.001**
Adolescents' education (Reference: University level)		
School level	1.8 (1.4–2.4)	<0.001**
Maternal education level (Reference: University level)		
Illiterate	0.1 (0.03–0.11)	<0.001**
School level	0.6 (0.5–0.8)	<0.001**
Paternal education level (Reference: University level)		
Illiterate	2.4 (1.1–5.0)	0.02*
School level	0.8 (0.6–1.1)	0.23
Primary caregiver (Reference: Both parents)		
Other caregivers	3.9 (2.2–6.9)	<0.001**

Variables entered in step 1: adolescence stage; gender; residency; weight status; adolescents' education level; maternal education level; paternal education level; primary caregiver; working status; school type; receiving nutrition education in schools' curriculum; AOR, adjusted odds ratio; CI, confidence interval; *significant at p-value < 0.05; ** significant at p-value < 0.001.

51.9% of Chinese adolescents recruited from grades 7,8,10, and 11 at 239 schools in Chongqing were observed to have poor nutrition literacy scores (34). However, a study in North Central Florida, United States showed that adolescents had sufficient levels of nutrition knowledge and literacy (7).

Noteworthy is the fact that research has found that adolescents populations in developed nations tend to have higher levels of nutrition literacy than their counterparts in developing ones. The latter observations were explained by the fact that developed countries had made greater investments in the invention of nutrition education policies for use in and outside the school environment (28). In the same manner, the observed findings could be justified by the fact that 68.6% of Saudi adolescents reported not getting nutrition education in schools. This is supported by findings from recent national research that found no nutrition education programs were offered at any of the 10 elementary schools in Saudi Arabia that participated in the study. More than half the students (55.8%) also stated that they were not taught any classes about nutrition or healthy diets. Also of interest, 64% of teachers in Riyadh, Saudi Arabia lacked access to adequate nutrition curricular materials, and 70% were not trained adequately in nutrition education (35).

Not only do schools fail to educate their students about nutrition and eating healthy, but their canteens also sell unhealthy food. One study found that the diet provided to high-school students in Makkah, Saudi Arabia, was high in sugar and sodium and deficient in calcium, iron, and vitamin D, which is cause for concern (36). Most school food service supervisors in the investigated schools were not trained in nutrition, yet they were responsible for ordering food and creating meal plans (31). Multiple studies (26, 37, 38) confirmed these results by revealing that Saudi adolescents have poor dietary practices and food preferences. Of the 1,133 high school students surveyed, only 27.7% ate breakfast daily on average. Even more concerning, only almost three-fifths of adolescents (35.7%) and slightly more than a quarter (28.6%) said they ate vegetables and fruits every day. Also, more adolescents (37.1%) reported drinking fizzy beverages every day (26).

Lack of awareness of healthy food and unsupportive environment for healthy eating for adolescents may have an impact on the emergence of unhealthy eating habits. As a

result, overweight and obesity have often been noted as serious health issues among them, according to plenty of evidence (37–39). The aforementioned assumption may explain the high percentage (38.6%) of adolescents who are currently categorized as overweight or obese, as demonstrated by the current study. Despite the genetic predisposition to obesity, other pliable factors, such as nutrition literacy, may indeed contribute to the prevalence and burden of obesity. Referring to the socio-ecological model (SEM), the cumulative effects of individual, interpersonal, institutional, community, social and political factors affect the adolescent's health and nutrition status. SEM moves beyond solely focusing on individual's (adolescent's) risk factors; however, it represents the multi-level determinants of health (40).

Given the preceding debates, it is now crucial to demonstrate the courage necessary to create supportive school environments in the Kingdom of Saudi Arabia, generating favorable possibilities for nutrition education and enhancing students' nutrition literacy. The Centers for Disease Control and Prevention (CDC) recommends that schools create rules that encourage children to make healthy food choices. For behavior modification, the CDC recommends 40–50 h of nutrition education in this context. To intervene in the nutrition knowledge and skills of kids from diverse socioeconomic backgrounds and with varying dietary demands, schools are the best and most convenient places to do so. Sending out text messages with nutrition-related content or conducting group cooking sessions are two examples of how nutrition education could reach more people outside of the classroom setting (41). Improvements in eating behaviors, label reading, consumption habits, academic achievement, variety in the diet, and nutrient sufficiency have all been linked to higher levels of nutrition literacy in the MENA area (28). So, the school-based nutrition education method will help Saudi Arabia in various ways, such as strengthening the country's food security and addressing the underlying causes of adolescent malnutrition. There has to be strong support from policymakers, nutritionists, health promoters, and other stakeholders for equipping schools with the tools they need to implement effective nutrition education programs.

This study also shows that some factors, such as adolescents' gender, residence, education level, weight status, and the education level of their parents, are important in laying the foundation for their nutrition literacy. This finding is in line with previous research that linked dietary literacy with socioeconomic factors (14, 42, 43). Supporting present study findings, an Iranian study found that being female was a significant predictor of higher levels of nutrition literacy scores. Those females with higher nutrition literacy were more likely to use food labels, buy low-calorie foods, and pay attention to nutrition information. In addition, those who knew more about nutrition also ate less fried chicken and high-fat cheese (42). Furthermore, a similar study found that girls had better levels of functional nutrition literacy than boys (15). The gender of adolescents was also found to significantly correlate with their levels of nutrition literacy in a cross-sectional study of 803 adolescents aged 10–12 from elementary schools in Tehran city, Iran (44). A possible explanation for the disparity in nutrition literacy between male and female adolescents is that girls are more aware of their eating patterns due to concerns about their body image and ideal weight (45). Differential body image perception between the sexes has been documented in research. Girls, even at a young age, are more self-aware about how their weight affects their looks than boys. In addition, being overweight has a greater negative impact on females' self-esteem than on males' (46). This finding suggests that gender-specific approaches to nutrition education are necessary to meet the unique needs of female students without fostering negative body image or an unhealthy preoccupation with food while also aiming to pique boys' interest in nutrition and inspire them to learn more about it.

There was a 3 fold and 2 fold increase in the chance of nutritional illiteracy among those who were underweight and overweight, respectively in the current study. There is a lack of consistency among the studies that have looked at how BMI and nutrition literacy are associated (35, 36), and the results may vary according to age and gender (34, 42, 44, 47–49). Overall, those in their late adolescence stage (17–19 years old) and females were more prevalent in the current study. This result is assumed as adolescents' body weight is determined by a variety of interrelated external factors, such as eating patterns, food preferences, and dietary patterns (50), all of which are founded on the level of nutrition literacy. When it comes to adolescent nutrition in terms of its diversity and sufficiency, NL plays an important role. Adolescents with higher FNL are also less likely to be overweight or obese than those with lower FNL (17). Fried meals, sugary drinks, red meat, and processed foods are more common among individuals with low NL, whereas vegetables, olive oil, and nuts are more common among those with high NL (51). Additionally, a study shows that improved energy balance, lower sugar intake, and higher dairy intake are all connected with higher FNL, which in turn has a beneficial effect on adolescents' weight. Previous studies have linked high INL with higher energy scores, and high CNL with more fruit and vegetable consumption (18). Hence, investments in nutrition literacy, as previously discussed, are essential to break the intergenerational cycle of malnutrition in our nation, as obesity in adolescence is most likely to persist into adulthood. A systematic review and meta-analysis showed that nearly 55% of obese children would become obese in adolescence, 80% of obese adolescents will remain obese in adulthood, and 70% will be obese after the age of 30 (52).

Parental-related factors, including the education level and the primary caregiver, were also shown to contribute to determining adolescents' nutrition literacy level in the present study. In this regard, one study showed that low-educated

parents typically have children with unhealthy eating habits (53). The family structure that a child grows up in will actively participate in developing and supporting behaviors that will stick with him or her throughout their life. Parental food habits and feeding strategies are the most dominant determinants of a child's eating behavior and food choices (54). Parents actively choose what to eat for the family, act as role models for dietary choices and patterns, and use feeding practices to bolster the development of eating patterns and behaviors that they find appropriate. According to studies, children's consumption of milk, fruits, and vegetables increased when they witnessed adults eating these meals (55). Parents are undoubtedly the first-ever teachers for their children; therefore, it is fundamental to include parents and adolescents in nutrition education sessions and activities for all planned school-based interventions in Saudi Arabia and other countries.

There were several of policy implications from this study. The economic, social, and health costs associated with obesity are significant. Regarding the prevention and control of NCDs, Saudi Arabia has made some progress in the right direction with regard to the national dietary goals (11). To achieve the 2025 global nutrition goals, Saudi Arabia focused on preventing an increase in childhood obesity and on reducing the prevalence of non-communicable illnesses by reducing the prevalence of their risk factors (56). Children in Saudi Arabia under the age of five are 6.1% overweight, and yet the country has made limited progress in reducing this rate. Few progress has been made toward their aim of preventing obesity, with an estimated 34.3% of adult men and 45.5% of adult women being obese (56). It's predicted that the rate of adolescent obesity in Saudi Arabia would keep climbing in the future years. This assumption is supported by data showing that Saudi adolescents frequently eat at fast food restaurants, rarely eat breakfast, and eat very little fruits and vegetables (25).

Policymakers, researchers, and other stakeholders in society would do well to assess and develop the NL of adolescents because doing so may improve their weight status by improving their ability to make food choices, perceive food labels, implement food safety precautions, apply healthy cooking methods, and adopt appropriate dietary recommendations (57). The environment of the schools might be an excellent starting point for teaching adolescents about their food and the appropriate dietary patterns and eating behaviors.

4.1. Study limitations and strengths

The findings of the current study should be interpreted with caution as there are some study limitations. Similar to all cross-sectional design-based studies, it is inappropriate to infer causal relationships between the study variables. In addition, the online self-administered could lead to some bias in the information collected from adolescents as the nutrition literacy topic is still emerging in our region, and it could be more helpful to conduct face-to-face interviews with the adolescents to fill in the data more accurately. Nonetheless, online surveys save time and do not require logistical planning. Moreover, assessments of adolescents' eating habits or diet quality were not performed, although they might associate with the nutrition literacy levels of adolescents. On the other hand, to the best of the author's knowledge, this study is the first of its kind in our nation and could serve as an inspiration for future school-based interventions which should cover adolescents and their parents, particularly in school settings.

5. Conclusions

In conclusion, the NL among Saudi Arabian adolescents was investigated here for the first time using a group-specific, validated instrument. The author found that a large percentage of Saudi adolescents demonstrated poor nutrition literacy. Additionally, adolescent's gender, place of residence, weight status, educational level, primary caregiver, or parents' level of education were found to influence NL. These findings suggested that programs targeting NL adolescents could help bring down the risk of obesity. When people make better eating choices and engage in regular physical activity, they reduce their risk of becoming overweight or obese. Adolescence is an important time for forming dietary patterns, which are influenced by a variety of factors including an understanding of nutrition. To equip adolescents and school-age children with the sufficient nutrition knowledge and skills essential to encourage healthy eating decisions, nutrition literacy is one of the most flexible elements that may be perfectly intervened in school settings. Without a doubt, this calls for a holistic strategy on the part of education and health ministries, nutrition professionals, educators, parents, and eager, motivated teenagers. Mechanisms, like the impact of NL on food consumption and exercise levels, should be evaluated in future research.

Data availability statement

The datasets presented in this study are not readily available due to confidentiality reasons, requests to access the data can be directed to the author KB, kbookari@taibahu.edu.sa.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethical Committee at Taibah University, Saudi Arabia. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

KB conceived the study, conducted the analyses, interpreted the results, wrote the paper, critically reviewed the manuscript, and approved the final version submitted for publication.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The role of breastfeeding as a protective factor against the development of the immune-mediated diseases: A systematic review

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Introduction: Breast milk is rich in nutrients and immunological factors capable of protecting infants against various immunological diseases and disorders. The current systematic review has been framed with the objective of studying the role of breastfeeding as a protective factor against the development of immune-mediated diseases.
Methods: The database and website searches were performed using PubMed, PubMed Central, Nature, Springer, Nature, Web of Science, and Elsevier. The studies were scrutinized based on the nature of participants and the nature of disease considered. The search was restricted to infants with immune-mediated diseases such as diabetes mellitus, allergic conditions, diarrhoea, and rheumatoid arthritis.
Results: We have included 28 studies, out of which seven deal with diabetes mellitus, two rheumatoid arthritis, five studies about Celiac Disease, twelve studies about allergic/ asthma/wheezing conditions and one study on each of the following diseases: neonatal lupus erythematosus and colitis.
Discussion: Based on our analysis, breastfeeding in association with the considered diseases was found to be positive. Breastfeeding is involved as protective factor against various diseases. The role of breastfeeding in the prevention of diabetes mellitus has been found to be significantly higher than for other diseases.

KEYWORDS
allergy, breastfeeding, immunity, diabetes, infants, lactation

Introduction

During the first few years of a person's life, the immune system may be readily reshaped, which is important for achieving full protection against infections and the ability to tolerate non-harmful environmental substances to an adequate degree (1). Breastfeeding is geared to the needs of the newborn, and it may compensate for the relative inadequacy of the host defence by delivering substantial quantities of both nonspecific and pathogen-specific secretory IgA (sIgA) (2). Breastfeeding is adapted to the requirements of the infant (1). These antibodies, which are generated as a result of the earlier exposure to infectious agents by the mother, are capable of binding to potentially dangerous pathogens and rendering them inactive (1). Breast milk includes various additional nonspecific components that have antimicrobial properties or give protection to the newborn *via* different channels (3). These substances are present in addition to the antibodies that are present in breast milk (3). It's possible that the immunological, hormonal, enzymatic, trophic, and/or bioactive substances that are found in breast milk might provide some degree of passive protection (4). Other components, including as macrophages and leukocytes, which are predominantly present at

the start of breastfeeding, may have a stronger modulatory influence on the immune system of the neonate and give further protection (5).

Breastfeeding has been regarded as the major protective factor in the lives of infants. The primary milk produced by the mothers is referred to as colostrum, which is found to be rich in immunologically active molecules and various nutrients and vitamins that are absolutely necessary for the growth of the infants (6). Infant's breastfed during their early life have developed immunity against various diseases considerably (7). The infants provided with breastfeeding have also been found to be devoid of malnutrition conditions (8). According to the World Health Organization, breastfeeding helps children attain the necessary nutrients for the first year of their lives (9). Breastfeeding for the initial six months period of life plays an important role in helping the infants to attain optimal growth during their childhood (10).

Breastfeeding aids nutritional benefits and illness protection not only to the infants, but also to the lactating mothers (11). The lactating mothers involved in breastfeeding for longer period are being protected from pregnancy obesity and the risk for cancers in breast and ovaries are observed to be reduced (12). The risk of brittleness in bones leading to osteoporosis was also reported to be lower in mothers who breastfed (3–6 months) their children (13). The risk for immune system mediated diseases and disorders may be decreased by breast milk and breastfed infants, since the breast milk is rich in immunoglobulins that are specific to allergens (14). Thus, we concentrated on reviewing research, especially those including infants with of immune-mediated diseases.

Materials and methods

Study design

The database search was carried out by the reviewer on various publication sites such as PubMed, PubMed Central, Nature, Springer, Nature, Web of Science, and Elsevier. The keywords for searching the studies are: breastfeeding, breast milk, human milk, immunity, diabetes, diabetes mellitus, rheumatoid arthritis, diarrhoea, hypersensitivity, allergens, allergic reactions, erythematosus, colitis, hypoglycemia, hyperglycemia, infantile diabetes and protective factor. The duplicate and irrelevant articles were removed, and the data screening was done.

Inclusion criteria

Only research articles relevant to the current study have been selected. The original research articles, including the *in vivo* studies, were majorly focused, and the studies involving human participants were given higher priority. The recent studies involving human participants with immune-related diseases diagnosis were considered, along with the *in vivo* studies involving the management techniques for immune-related clinical conditions.

Review articles, systematic reviews, and meta-analysis reviews were excluded from the study. The research articles that did not deal with the considered clinical conditions as well as the studies involving *in vitro* analysis were excluded from the study. The articles in which breastfeeding was not associated with the considered immune-related conditions were excluded.

The articles selected on the basis of inclusion and exclusion criteria have been screened manually by the authors for the inter-relationship between breastfeeding and respective clinical conditions. The articles that met the eligible criteria were selected, and data extraction was carried out.

Data extraction

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines Liberati et al. (15) were followed for the data extraction procedure. The details of the eligible articles were extracted from the template obtained from the PRISMA website. The details of the included articles contain: (1) year of publication; (2) number of participants; (3) gender of the included participants; (4) age of the participants; (5) race, ethnicity or religion of the participants; (6) immunological disease considered for the analysis; (7) hypothesis framed for the study; (8) methodology used to test the framed hypothesis; and (9) results obtained from the study. A total of 28 articles were considered and presented in the current review.

Results

Initial screening of articles included around 10,849 articles from the previously mentioned databases and web-sites, from which 411 articles were considered after removing the duplicated and irrelevant articles. Following that, 295 articles were excluded since the presentation of results was found to be irrelevant after reading, and finally 116 articles were fully screened for the current study. After the exclusion of articles based on inclusion and exclusion criteria, 28 research articles were fully analyzed and considered for the review. After screening the abstracts of 116 full-text articles, 87 articles were removed, and 28 articles were found to be in coherence with the current study (**Figure 1**).

The 28 articles presented in the current review comprise seven studies on "diabetes mellitus with breastfeeding", two studies about "rheumatoid arthritis and breastfeeding", five studies about " role of breastfeeding in celiac disease, twelve studies about allergic/asthma/wheezing conditions and one study on each of the following diseases in association with breastfeeding: neonatal lupus erythematosus and colitis, and. The characteristics of the 28 articles included in the systematic review are summarized in an Appendix in Table A1.

Breastfeeding and diabetes (type 1 and 2)

Type 1 diabetes is one of the auto-immune diseases that may affect individuals in their early life. It is caused by the autoreactive T cells that ultimately terminate the function of the pancreas's beta cells to produce sufficient insulin. However, its pathological condition may manifest from ten to fourteen years. Nevertheless, its clinical symptoms may occur as early as nine years or as late as

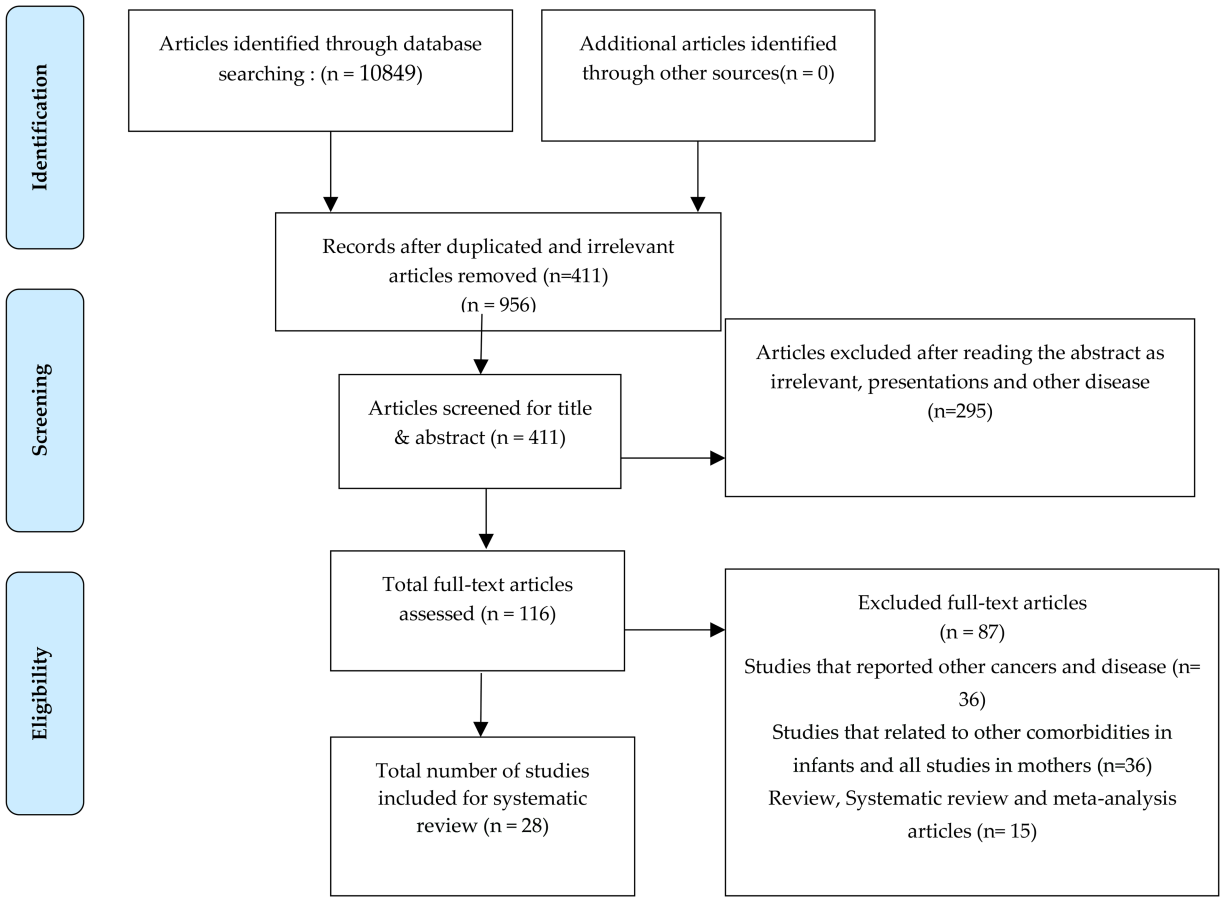

FIGURE 1
PRISMA flow chart.

90 years of life (16). Type 2 diabetes is exclusively a metabolic disorder which is meeting the characteristic of type 1 diabetes leads to high blood sugar levels (17). However, the pathogenesis of type 2 diabetes is also documented as an autoimmune disease based on the presence of autoantibodies against beta cells of the pancreas in the blood of people with type 2 diabetes (18, 19).

We have identified six research articles (20) involving the relationship between breastfeeding and diabetes conditions. Three of the studies were reported with type 1 diabetes and rest three studies with type 2 diabetes.

Type 1 diabetes: Two studies were undertaken in Germany, with sample sizes of 990 Rosenbauer et al. (20) and 324 Schaefer-Graf et al. (21). The research that was carried out by Lund-Blix et al. (22) consisted of two population-based cohorts of children who were tracked from the time of their birth (1996–2009) until the year 2014 (in Denmark) or 2015 (Norway), provides evidence in support of the claim that breastfeeding lowers the chance of developing type 1 diabetes.

Type 2 diabetes: Children and adults who received their nutrition from their mothers' breasts rather than from bottles and who were breastfed for longer periods of time throughout infancy had lower rates of type 2 diabetes and lower insulin resistance than those who received their nutrition from bottles (23, 24). It has been hypothesised that variations in the nutritious content of the milk, patterns of baby weight growth, or acquired eating behaviour between infants who are breastfed and babies who are bottle-fed are related to an increased risk of developing diabetes in later life (23). There have only been a few studies that look at diabetes risk in connection to the age at which supplemental meals are introduced to infants (25–27). Longer breast-feeding duration was related with lower fasting insulin concentrations and insulin resistance at 5 years, but not at 9.5 years, according to a research done by S. R. Veena et al. (25). There was no significant relationship found between the age at which a person began eating complementary foods and their glucose or insulin levels. The increased breastfeeding period has been found to be positively associated with the prevention and low risk of type 2 diabetes in lactating mothers Stuebe et al. (26) and children's (27) in the United States population. Similarly, the breastfeeding has also been observed to decrease the risk for type 1 diabetes in females who fed for longer period (22). The susceptibility and possibility of acquiring type 2 diabetes is found to be directly proportional to the period of lactation and breastfeeding in females (28). The presence of a diabetic condition in a breastfeeding female has no effect on the health status of the infants, such as obesity nature or diabetic occurrence (29, 30). Breastfeeding has been reported to be

one of the environmental factors that is responsible for children being overweight inversely (30). Reduced breastfeeding has been associated with increased child obesity and type 1 diabetes incidence (31). The risk and occurrence of type 2 diabetes in women may be reduced by suggesting breastfeeding (32). Therefore, breastfeeding plays an important role in protecting infants as well as mothers from the risk of type 1 and type 2 diabetes.

Rheumatoid arthritis and breastfeeding

Rheumatoid arthritis is a chronic and systemic inflammatory illness that causes irreparable damage to cartilage and bones (33). This damage is caused by inflammation in the synovium of the joints revealed that insulin resistance, a significant contributor to the development of diabetes mellitus, is quite common in people with rheumatoid arthritis (33). In genetically sensitive hosts, environmental stressors may trigger Juvenile idiopathic arthritis (JIA). Shenoi et al. (34) found no link between early infection, prenatal factors, or stressful events. Unfortunately, it has been found that the number of studies that link rheumatoid arthritis and breast milk is significantly low, and the studies that report an association between the two have failed to identify the proper underlying aetiology of rheumatoid arthritis in association with breast milk or breastfeeding in infants (35).

Two studies that show a lower risk of rheumatoid arthritis in children who are breastfed have been taken into consideration in the present systematic review (36, 40). Alotiby, A et al. (36) conducted research that shown the relevance of breast milk to neonates in decreasing the risk of Rheumatoid Arthritis (RA) when compared to formula milk consumption. They investigated the differences in the beginning of the disorder in children who were nursed, children who were not breastfed, and children who were given both breast milk and formula (mixed-fed children). Breastfed children (28.3%), formula-fed children (21.7%), and mixed-fed children (50.0%) were the most common. This difference in feeding method was statistically significant. Formula feeding markedly increased the incidence of RAin children. Hence, exclusive breastfeeding may reduce the risk of RA (36).

The immunological memory of the mother is passed on to her child *via* breast milk, and breast milk includes a range of immune-modulating chemicals, including immune cells and their products such as cytokines (37). Breast milk also allows the mother's immune memory to be passed on to her child. Immunological imprinting and programming of the newborn may be accomplished *via* breastfeeding (37). Therefore, breastfeeding makes a contribution to the development of the immune system of the newborn (38, 39). According to the findings of Kindgren, E. et al. (40), an in-creased risk of juvenile idiopathic arthritis was related with a shorter overall period of breastfeeding as well as a shorter duration of exclusive breastfeeding.

There was an association found between the early introduction of formula (before the age of 4 months) and an elevated incidence of JIA. When potentially confounding factors were taken into account in the model, none of the correlations lacked their statistical significance (40). Breastfeeding may provide some protection against the development of juvenile idiopathic arthritis, according to one finding (41). According to the findings of another re-search, infants who subsequently developed oligoarticular JIA tended to have shorter nursing durations (42). It is recommended that mothers be encouraged to nurse their newborns exclusively for the first four months Kindgren et al. (40), if at all feasible, and then to maintain partial nursing for a prolonged period of time after the introduction of foreign proteins through food.

Prevention of infantile diarrhea by breastfeeding

It has been shown that beginning breastfeeding as soon as possible and continuing it exclusively protects new-born babies against death due to diarrhea (43). A self-limiting characteristic of the human body that is usually caused by gastroenteritis is termed "diarrhoea." It is characterized by having loose stools abnormally frequently in a single day (44). The major causes of diarrhoea include dietary habits causing food poisoning or allergies as well as certain medications. We have identified three studies involving the analysis of breastfed infants and their susceptibility to diarrhoea.

We have summarised a study conducted on Qatari children in the year 2009 by Ehlayel et al. (45). The study was targeted at 1,500 mothers and their infants and children aged 1 to 5 years and the response rate was agreed with 1,278 participants. The breastfeeding of the children varied significantly ($p < 0.001$) from 11.4 ± 6.7 months (longer) to 9.2 ± 4.1 months (shorter). In this study, around 11.4% higher risk and susceptibility were observed in the children who received shorter breastfeeding periods, indicating the protective role of breastfeeding against infantile diarrhoea (45).

The other two studies included 93 mother and infant pairs in the Mexican population in the years 2004 and (46, 47). The mean age of the infants was 6 months. The oligosaccharide content present in breast milk influences the diarrhoea in infants and children. The oligosaccharide contents in breast milk were proved to influence the diarrhea in infants (48). The breast milk contains fucosyl oligosaccharides as its major component, and the fucosyl oligosaccharides have a role in controlling diarrhoea in infants in a positive manner *via* innate immune response (47).

The effects of ceasing breastfeeding in the early period and the influence of termination on diarrhoea in infants are adverse. The early termination of breastfeeding increases the risk of infantile diarrhoea (49). Reduced breast-feeding in infants has been positively influenced by the mortality of children along with diarrhoea and other clinical conditions (50).

Breastfeeding and neonatal lupus erythematosus

A clinical condition caused in infants due to the presence of autoantibodies in lactating mothers is neonatal lupus erythematosus. It is a rare autoimmune disorder (51). Due to the limited number of studies linking breast-feeding and neonatal lupus erythematosus in infants, we have identified one study

involving a male infant of 4–6 months. Intense immunoglobulin levels of IgG and IgA were identified in the breast milk, which induced an erythematosus condition in the infant. The antibodies of the lactating mother were found to induce autoimmunity in the infants, and the lesions in neonatal lupus erythematosus conditions were adverse with an increase in breast-feeding (52). They examined the mother's breast milk from an immunological standpoint for their research. Anti-bodies with significant positive IgG and IgA reactivity against nuclear and Ro targets were found in the mother's breast milk, which was a surprise. After this, the doctor recommended stopping nursing, and three weeks later, the lesions disappeared. Since then, the child has been healthy and has not had any diseases. It is possible to draw the conclusion from this that the illness known as neonatal lupus erythematosus is caused by a passive transfer through the placenta of maternal autoantibodies Vanoni et al. (53), the majority of which are directed against the Ro antigen.

Breastfeeding against colitis

Colitis is a clinical condition in which the large intestine is inflamed. One study has been identified and presented that represents the role of breastfeeding in colitis disease. No studies involving human participants were eligible for the current systematic review, and hence, an *in vivo* study involving interleukin-10 (IL-10) deficient mice is being considered. The duration of breastfeeding as well as breast milk has an impact on the development and progression of colitis inversely (54). Inflammatory bowel disease, a gastrointestinal inflammatory condition that includes Crohn's disease and colitis, is being reduced in infants who were breastfed for a longer period when com-pared to children who had breastfeeding for a shorter period (55).

Breast feeding and celiac disease

The impact of childhood infections on the development of celiac disease is debatable. Although frequent infections during the first 18 months of life have been linked to an increased risk of celiac disease later in life (56–58), acute infections at the time of gluten introduction have no effect on disease risk in the general population (59). Coeliac disease is multifactorial, resulting from genetic and environmental factors (59). HLA and non-HLA genes are involved, and gluten is a key environmental factor because the disease remits when gluten is eliminated. The important case-control study by Ivarsson et al. 2002 concludes that breast milk protects under-2-year-olds from coeliac disease (60).Different studies such as case control, follow-up studies, comparative studies showed a significant correlation between breast feeding and coeliac disease (60–63). Breastfeeding (62, 64) and later gluten introduction (61, 63) reduced celiac disease incidence. Different populations had delayed celiac disease onset (65–67). Elena Lionetti (68) reported the administration of gluten in the early of life was linked to a development of illness in the later stage of life.

Role of breastfeeding in hypersensitivity and allergic conditions

An abnormal or altered immunological reaction that is in response to the untimely response of the immune system is termed hypersensitivity (69). The hypersensitivity or allergic reactions is majorly targeted towards harmless foreign substances resulting in damage of tissues (69). One study regarding hypersensitive and allergic reactions has been included in this current review, which includes the screening of 1,278 lactating Qatari mothers and their infants and children (70). The mean age of the participating mothers was 32.5 years, and the children were 2.5 years old. The period of the study was from around the years 2006 to 2007. More than 59% of infants were exclusively breastfed, 28% were partially breastfed, and the remaining infants were not breastfed. The study report revealed a significant variation ($p < 0.01$) in the occurrence of allergic reactions (70). Allergy and hypersensitive reactions are prevented in infants receiving breast milk, indicating the protective nature of breast milk against hypersensitivity and allergic reactions (71–80).

A respiratory condition called asthma is being triggered by the immune cells as the result of allergic response to certain environmental factors (70). The breastfeeding influences the risk of developing asthma (81). According to Malcolm Sears et al. (82), nursing does not prevent children from atopy or asthma and may potentially increase the risk. Breast milk has been shown to transport food molecules intact from the maternal body to the infants (81). A study has reported hypersensitive allergic reactions towards fish by infants due to increased dietary fish intake by the mother (83). Similar allergic reactions have also been observed in infants in response to egg intake as well as peanut intake by lactating and breastfeeding mothers (84).

Discussion

This structured and systematic review on breastfeeding as a protective role against the development of auto-immune diseases identified around 20 relevant and appropriate articles related to breastfeeding and autoimmune diseases. Most of the considered investigations were cohort and follow-up studies on lactating mothers and breast-feeding infants. Many research articles were published in accordance with breastfeeding and its protective role against immune-mediated diseases. The objectives of interest were breastfeeding, ingestion of breast milk, and immune-related diseases in infants. It has been reported that the breast milk of diabetic mothers fed to their infants for a longer period as well as in larger volumes induces childhood obesity (85). But, in this review, we have suggested and provided evidence that childhood overweight as well as childhood obesity is prevented by longer breastfeeding than partial breastfeeding. The authors would also like to add the fact that the glucose content in breast milk of diabetic and non-diabetic mothers is similar (86).

Few studies have been reported in favour of breastfeeding as a protective factor against rheumatoid arthritis, which is currently

being discussed in this review. Children's exposure to breastfeeding for less than four months increases the risk of rheumatoid arthritis during their childhood stage (87). Middle-aged and elderly women who had been breastfeeding their children for an extended period were less prone to rheumatoid arthritis, and breast-feeding is observed to be positively associated with the prevention of rheumatoid arthritis in infants during their childhood and in mothers at their elderly age (35). The relationship between breastfeeding and rheumatoid arthritis have concluded that the breastfeeding eventually reduces the susceptibility and risk of rheumatoid arthritis irrespective of feeding period (88).

A skin condition called eczema has been reported as one of the allergic conditions prevalent in early childhood as well as in infants and has been associated with the food intake of the lactating mother (89). Asthma and other respiratory infections in the early stages of a child's life have been found to be associated with breastfeeding inversely, i.e., the longer the breastfeeding, the lower the risk of respiratory infections (90, 91). An allergic reaction in the nose resulting in rhinitis has been reported to be reduced in breastfed children Bloch et al. (92). A hypothetical suggestion is to be provided in the case of allergic and hypersensitivity reactions to breastfeeding, since breastfeeding may induce hypersensitive reactions in some cases as well as protection in a few cases, as reported in this review.

A few studies have reported that the diabetic condition, accompanied by a gluten intolerance clinical condition, celiac disease, is being influenced by breastfeeding (93). The risk for developing autoimmune nature in the infants increases when the microbial infections are diagnosed before 9th month of their life (94). Here, the authors present a contrasting review that shows autoimmune conditions are prevented and protected in children who were breastfed for more than 4 months. Breastfeeding favours the immune system of infants to produce necessary immunity (95). Infants fed with breast milk are being observed to attain support for their immune systems that has yet to be matured. The mechanism involves the components of breast milk like anti-inflammatory cytokines, which is an immune-modulating compound (96).

At birth, a newborn infant is immediately exposed to a vast array of microbes from the environment, but primarily from the mother (97). However, breast milk then "feeds" the gastrointestinal tract both directly (maternal milk microbes) and indirectly (through the birth process) (97). In breastfed infants, the microbiome predominantly consists of Bifidobacterium (B breve, B longum, and B bifidum) (98). In contrast, the microbiome of formula-fed infants is more diverse, with the increased relative abundance of Bacteroidetes and Firmicutes, and with increased Clostridium difficile (98). In contrast, the microbiome of formula-fed infants is more diverse, with an increased relative abundance of Bacteroidetes and Firmicutes (99). There is a complex relationship between breast milk and the infant's microbiome (98). This relationship involves the transfer of immunoglobulins, bacteria, viruses, and bacteriophages (viruses that parasitize a bacterium by infecting it and reproducing inside it) from the mother to the infant through the mother's only milk. The microbiome begins to resemble that of an adult by the third year of life, and the sequential acquisition of gut microbes early in life has a long-lasting effect on gut health. This occurs as the micro-biome gradually transforms to match that of an adult. A disruption in the establishment of this microbiome has been linked to increased risks of obesity, diabetes, and mental health disorders, as well as immune-mediated and inflammatory conditions such as inflammatory bowel disease and atrophy. Breastfeeding an infant is related to a lower risk of diarrhoeal illness than formula-feeding an infant. The variations in the microbiota of breastfed and formula-fed infants continue to exist beyond six months (100, 101). The current review also reported a similar suggestion that breastfeeding favours the maturation of the immune system in infants.

Conclusions

Based on all the literature surveyed for the current systematic review, we conclude that breastfeeding infants anonymously helps them to build a mature, strong, and healthy immune system against immunological conditions. The breastfeeding helps the infants to protect against certain acquired immunological conditions.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author/s.

Author contributions

Amna Alotiby is a solo author for this paper. All authors contributed to the article and approved the submitted version.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix A

TABLE A1 Characteristics of the included studies.

Sl.no	Name of the Authors	Gender	Infant /Maternal focused study	Number of Study Participants	Age Group	Ethnicity / Race / Study Region	Type of Disease	Hypothesis Framed	Methodology Used	The outcome of the Study
1	Alotiby et al. (36)	Male - 29; Female – 31	Infant	60	1 to 16 years	Saudi Arabia	Rheumatoid Arthritis and Inflammatory Bowel Disease	To determine the relationship of breastfeeding with Rheumatoid Arthritis and Inflammatory Bowel Disease	A cross-sectional study	Breastfeeding reduces the risk of Rheumatoid Arthritis in infants
2	Kindgren et al. (40)	Not disclosed	Infant	10,565	0 to 18 years	Swedish	Rheumatoid Arthritis	To study the influence of early breastfeeding on later development of Rheumatoid Arthritis	A case control study in a prospective birth cohort	Longer breastfeeding reduces the risk for Rheumatoid Arthritis in the later age of childrens
3	Kemppainen et al. (61)	Not disclosed	Infant	6,327	1 to 4 years	United States and Europe	Celiac Disease	To determine the relationship of breastfeeding with celiac disease	A follow-up study	Breastfeeding reduces the risk for celiac disease
4	Lund-Blix et al. (22)	Not disclosed	Infant	504	6 to 18 months	Norwagean and Danish	Type 1 Diabetes	To find the relation between type 1 diabetes and breastfeeding	Two population based cohort and follow-up study	Breastfeeding reduces incidence of type 1 diabetes
5	Shenoi et al. (34)	Male - 126; Female - 237	Infant	363	8 to 15 years	Not Disclosed	Juvenile Idiopathic Arthritis	To investigate the association of breastfeeding and development of Juvenile Idiopathic Arthritis	Case-control study	no association was observed
6	Palma et al. (62)	not disclosed	Infant	164	1 to 4 months	Spain	Celiac Disease	To find whether breastfeeding protect children from developing celiac disease	PROFICEL study	Breastfeeding has a protective role against celiac disease
7	Veena et al. (25)	Not disclosed	Infant	518	3 months to 18 months	India	Diabetes mellitus	To examine whether breast-feeding is associated with lower glucose concentrations and insulin resistance	Follow-up study	Longer duration of breastfeeding protects against glucose intolerance and insulin resistance in children
8	Mayer Davis et al. (27)	Female	Infant	247	10 to 21 years	African Americans	Type 2 Diabetes	To evaluate the association of breast-feeding with type 2 diabetes incidence	Case control study	Breastfeeding is protective against development of type 2 diabetes in youth
9	Kristiana Gray et al. (52)	Male	Infant	1	4 months	United Kingdom	Neonatal lupus erythematosus	To predict the breast milk and lupus interaction	Single case study	Breast milk contained immunoglobin increasing the lupus lesions
10	Bener et al. (70)	Not disclosed	Infant	1,278	0 to 5 years	Qatari children	Allergic diseases	To assess the relationship between breastfeeding and the development of childhood asthma and allergic diseases	A cross sectional study	Breastfeeding prevents asthma and hypersensitivity reactions

(*continued*)

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TABLE A1 Continued

Sl.no	Name of the Authors	Gender	Infant /Maternal focused study	Number of Study Participants	Age Group	Ethnicity / Race / Study Region	Type of Disease	Hypothesis Framed	Methodology Used	The outcome of the Study
11	Rosenbauer et al. (20)	Not disclosed	Infant	990	Less than 5 years	Germany	Type 1 Diabetes	To evaluate the association between type 1 diabetes risk and breastfeeding in preschool children	Case-control study	Breastfeeding prevents the development of type 1 diabetes
12	Schaefer-Graf et al. (21)	Male - 175; Female - 149	Infant	324	Children (Not disclosed)	German	Type 1 Diabetes	To determine the association of breast-feeding and early childhood overweight in children from mothers with gestational diabetes mellitus	Follow-up demographic study	Breastfeeding >3 months: does not cause infant overweight; Brestfeeding <3 months: associated with infant overweight
13	Young et al. (32)	Not disclosed	Infant	138	<18 years	Native Canadian	Type 2 Diabetes	To determine whether breastfeeding reduces the risk of type 2 diabetes among Native Canadian children	Case-control study	Breastfeeding reduces the risk of type 2 diabetes in Infant
14	Ivarsson et al. (60)	Not disclosed	Infant	1,881	0 to 2 years	Swedish	Celiac Disease	To compare the effects of breast feeding on risk of celiac disease	A population-based incident case-referent study	Breastfeeding reduces the risk for celiac disease
15	Sollid L.M. et al. (63)	Not disclosed	Infant/Child	1,881	1 to 15 years	Swedish	Celiac Disease	To find whether breastfeeding protect children from developing celiac disease	population based case control study	breastfeeding reduces the risk of celiac disease in early childhood and also during the subsequent childhood period.
16	Elena Lionetti (68)	Not disclosed	Infant/Child	832	6 months to 10 years	Italy	Celiac Disease	To determine the facor of gluten in the diet of infants for the development of celiac diasease with their age	Comparative study	Gluten diet did not affect for the development of the diseases in infant stage but made a significant difference by the development of the diseases in later of their life.
17	Malcolm Sears et al. (82)	Not disclosed	Infant	1,037	3 years	Newzealand	Asthma and Atopy	To assess long-term outcomes of asthma and atopy related to breastfeeding	Birth cohort study	Breastfeeding does not protect children against atopy and asthma and may even increase the risk
18	U. Peters et al. (64)	Not disclosed	Infant	280	1 to 10 years	Germany	Celiac Disease	To investigate the association between the duration of breast-feeding and celiac disease	Case-control study	Breastfeeding has a significant protective effect on the incidence of celiac disease
19	Yamakawa, M et al. (71)	Male-18 186 Female-17 029	Infant	35,215	6 to 42 months	Japan	Asthma	The associations between breast-feeding and hospitalization for asthma in early childhood	longitudinal survey	Beneficial effects of breast feeding on hospitalization for asthma in early childhood.
20	M.B. Azad et al. (72)	Not disclosed	Infant	2,773	3 to 12 months	Canada	Wheezing	association of breastfeeding and wheezing in the first year of life	Longitudinal study	Breastfeeding appears to confer protection against wheezing in a dose-dependent manner among infants born to mothers with asthma

(*continued*)

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TABLE A1 Continued

Sl.no	Name of the Authors	Gender	Infant /Maternal focused study	Number of Study Participants	Age Group	Ethnicity / Race / Study Region	Type of Disease	Hypothesis Framed	Methodology Used	The outcome of the Study
21	van Meel, E.R et al. (73)	Not disclosed	Infant	4,464	Birth until 1 year of age	Netherlands	Asthma	To examine the associations of breastfeeding, with lung function and asthma	population-based prospective cohort study	Shorter duration and non exclusivity of breastfeeding were associated with a lower forced expiratory volume (FEV1) and forced vital capacity (FVC) but not asthma
22	Huang, C et al. (74)	Male-18 6,536 Female-6,753	Infant	13,289	4–6 year	Shanghai (China)	Asthma, Allergies, and Airway Diseases	Associations of breastfeeding durations with prevalences of asthma, wheeze, hay fever, rhinitis, pneumonia, and eczema among preschool children	cross-sectional study	Findings support China?s national recommendation that mothers provide exclusive BF for the first four months, and continue partial BF for more than six months.
23	Peters, R.L et al. (75)	Not disclosed	Infant	3,663	1 year (followed for 6 years)	Australia	Asthma	Relationship between breastfeeding ever and duration on the 24 development of asthma and allergic asthma phenotypes	A population-based, longitudinal study	Longer duration of breastfeeding was associated with a reduced odds of asthma among children without eczema in the first year of life
24	Al-Makoshi, A et al. (76)	Male-327 Female-295	Infant	622	1–3-year	Riyadh, Central Saudi Arabia	wheezing/asthma and atopic disease	Investigated the prevalence of breastfeeding and its association with wheezing/ asthma and atopic disease	A cross-sectional study	Full breastfeeding is associated with reduced childhood wheezing and possibly asthma
25	Qu, F et al. (77)	Not clear	Infant	5,479	3–6 years	Beijing, China	asthma and allergy	prevalence and risk factors for asthma, allergy and related symptoms; and breastfeeding patterns and durations	A cross-sectional study	“More” breastfeeding appears to be protective against asthma and related symptoms
26	Hu, Y et al. (78)	Male- 5464 Female-5,000	Infant	10,464	6–11 years	Shanghai, China	Asthma and allergic	Examined whether breastfeeding modifed the efects of neonatal and familial risk factors on childhood asthma and allergic diseases	A population-based study	Longer breastfeeding duration was inversely associated with childhood Asthma and allergic diseases, and also reduced the OR of neonatal and familial risk factors on these diseases
27	Ehlayel, M.S. and Bener, A. (79)	Male- 632 Female-646	Infant	1,278	0 –5 years	Qatar	Allergic diseases	Assess the effect of Exclusive breast-feeding on the development of allergic diseases and eczema	A cross sectional study	Prolonged breast-feeding reduces the risk of developing allergic diseases and eczema even in the presence of maternal allergy
28	Obihara, C.C et al. (80)	Male-438 Female-423	Infant	861	6–14 Years	Cape Town, South Africa	Allergic diseases	Association between allergic disease in children and prolonged breastfeeding	A cross sectional study	Protective effect of prolonged breastfeeding on the development of allergic disease, particularly hay fever, in children born to nonallergic parents

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Status and correlates of food and nutrition literacy among parents-adolescents' dyads: findings from 10 Arab countries

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Background: Food literacy is capturing the attention worldwide and gaining traction in the Arab countries. Strengthening food and nutrition literacy among Arab teenagers are important promising empowering tools which can protect them from malnutrition. This study aims to assess the nutrition literacy status of adolescents with the food literacy of their parents in 10 Arab countries.

Methods: This cross-sectional study involving a convenient sample of 5,401 adolescent-parent dyads (adolescents: mean age±SD: 15.9±3.0, females: 46.8%; parents: mean age±SD: 45.0±9.1, mothers: 67.8%) was launched between 29 April and 6 June 2022 in 10 Arab nations. The Adolescent Nutrition Literacy Scale (ANLS) and the Short Food Literacy Questionnaire (SFLQ) were used to meet the study aims.

Results: More than one-quarter (28%) of adolescents had poor nutrition literacy, with 60% of their parents being food illiterate. The top three countries with nutritionally" less literate" adolescents were Qatar (44%), Lebanon (37.4%), and Saudi Arabia (34.9%). Adolescents' age, gender, education level, primary caregivers, employment status, and the inclusion of nutrition education in the schools' curriculum predicted the nutrition literacy levels of Arab adolescents. Besides, parental weight status, health status, parent's food literacy level, and the number of children per household were significant determinants too. Adolescents studying at a university and having parents with adequate food literacy had the highest odds of being nutritionally literate (OR=4.5, CI=1.8–11.5, p=0.001, OR=1.8, CI= 1.6–2.1, p<0.001, respectively).

Conclusion: Nutrition literacy inadequacy among Arab adolescents is a prioritized challenge to be tackled.

KEYWORDS

Arab countries, nutrition literacy, food literacy, adolescents, parents

1. Introduction

Malnutrition still rears its ugly head in many Arab countries, proposing that it is tremendously difficult for the region to meet the 2030 Agenda for Sustainable Development to reach "zero hunger" and eradicate all forms of malnutrition (1). High levels of food insecurity, malnutrition, and obesity is found in the Arab region, with 116 million people being food insecure, 43 million undernourished, and 115 million obese (2). Nonetheless, major inconsistencies among sub-regions do exist. Obesity is more prevalent in Gulf Cooperation Council (GCC); however, undernourishment is more of an issue in the least developed countries (LDCs) and Countries in Conflict (CICs) (3). Recent investigations show that the number of malnourished people in the Arab world increased from 4.8 million to 69 million between 2019 and 2020, accounting for nearly 16% of the population (4). In addition, the Eastern Mediterranean Region (EMR) is charaterized by its diversity into two main groups based on their Gross National Income (GNI): the oil producing high income countries and the low and medium income countries. Both countries are among the world's most vulneable to the dire impacts of climate change. The EMR suffers from extreme fluctuations in tempratures and precipitation as well as natural water and agricultural land scracity (5). It is predicted that these patterns will worsen in the coming years, with climate change, with intense pressure on agriculture thus compounding the effect of climate change with addditional significant challenges to livelihoods and food security (5). A functional food systems literacy is therefore required to aid people in communicating and collaborating on food system problems, including food insecurity, within dynamic learning approach addressed mainly to resolve the threats induced by the "nutrition transition" phenomena in the EMR. For instance, due to the "nutrition transition," adolescent obesity has reached a critical level in the Arab countries (6). Ensuring resilient food systems in the Arab world is challenging amidst the overwhelmed population growth, dwindling natural resources, and import dependency (7). Further, the COVID-19 crisis revealed how unprepared the region was to respond appropriately to the pandemic with food supply chains varying in complexity and vulnerable to disruption amongst sub-regions (8). Given these constraints, a multisector approach considering each policy's situation in the larger food environment and supply chain is required. Arab countries must invest in sectors having long-lasting effects, particularly education. In other words, equipping Arab people with sufficient nutrition knowledge could help meet a range of sustainable nutrition goals. Nutrition education works best in unique intervention points in the life cycle, particularly throughout adolescence (9). Adolescence, a period of life ranging from 10-to 19 years old (10), is an ideal time to plan, apply, and monitor nutrition interventions. Inadequate nutrition in adolescence can potentially retard growth and sexual maturation and displaces adolescents at high risk of developing chronic diseases (11). Referring to the Nutbeams' model in "health literacy," (12) two emerging concepts, "food literacy" and the "nutrition literacy," have grabbed the researchers' attention since 1990, who provided plenty of definitions for these two terms. Food literacy is beyond nutrition knowledge; it includes skills, and behaviors, from knowing where food comes from to the ability to select and prepare these foods appropriately (13). On the other hand, nutrition literacy is the ability of individuals to obtain, process, and understand the basic nutrition information they need to make appropriate nutrition decisions (14). The latter has been linked to improved diet quality, nutrient adequacy, food label reading, and food security (15–17). Upon this, Arab school is an ideal destination for creating synergies to contribute to sustainable development by offering a unique chance for the formal education system to improve students' nutrition literacy (18). All school-based activities advocating healthy eating, not only those held in the classroom, are part of an extended nutrition education curriculum known as a "macro-curriculum" (19). To date, the number of studies on adolescent nutrition literacy in the Arab world is limited. Therefore, we conducted this study to be the first to evaluate the nutrition literacy status of adolescents with the food literacy of their parents in ten Arab countries. The hypothesis anticipated in this study is that Arab adolescents express low levels of nutrition literacy, stressing the need to reach a regional consensus to integrate nutrition education into Arab schools' curricula.

2. Methods

2.1. Study design and eligibility criteria

A cross-sectional study using the snowball sampling method was conducted in Lebanon and nine other Arab nations: Bahrain, Egypt, Jordan, Kuwait, Morocco, Palestine, Qatar, Saudi Arabia, and United Arab Emirates (UAE). A self-administered questionnaire (82 items)[1] was disseminated to be completed by eligible adolescent-parents' dyads and kept open between 29 April and 6 June 2022. Calls for participation were performed via social network platforms and the research teams' networks. In each country, a convenient sample of parent's-adolescents dyads were collected. Research assistants were sending the links for eligible participants, based on the following eligibility criteria: (i) the adolescent is between 10 and 19 years old; (ii) either parent/caregiver (age more than 18 to 85 years old); (iii) having nationality of the mentioned ten countries; and consenting to participate. Besides, we aimed to reach only one adolescent per household. Overall, 5,401 adolescent-parents' dyads completed the survey and their data were considered for analysis.

1 https://survey.emfid.org/

2.2. Explanatory variables

The explanatory variables were as the follows: (i) demographic and socio-economic status of adolescents (age, gender, country of nationality, education level, working status, primary caregiver, parental education level, self-reported body weight and height), and whether nutrition education is a part of school's curriculum; (ii) demographic and socio-economic status of parents (age, gender, country of nationality, marital status, education level, spouse's education level, job type, number of co-residents per household excluding newborns, number of rooms excluding the kitchen and bathrooms, number of children, self-reported body weight and height, and health status). The body mass index (BMI) was calculated and evaluated per WHO recommendations (20).

2.3. Outcome variables

2.3.1. Nutrition literacy

The Adolescent Nutrition Literacy Scale (ANLS), developed by Bari (21), was used to assess adolescents' nutrition literacy. It compromised of 22 items under three sub-sections: Functional Nutrition Literacy (FNL) (7 items); Interactive Nutrition Literacy (INL) (6 items); Critical Nutrition Literacy (CNL) (9 items). Each item has a score range of 1–5. The scoring criteria is as the follows:

Total Nutrition Literacy (TNL): the sum of FNL, INL, and CNL (minimum-maximum score: 22–110; ≥ 66 is an average score).

FNL (questions 1–7): minimum-maximum score: 7–35 (≥ 21 is an average score).

INL (questions 8–13): minimum-maximum score: 6–30 (≥ 18 is an average score).

CNL (questions 14–22): minimum-maximum score: 9–45 (≥ 27 is an average score).

2.3.2. Food literacy

Parental food literacy was evaluated using the Short Food Literacy Questionnaire (SFLQ), developed by Gréa Krause et al. (22). It consists of 12 items (score range: 7 to 52; average score ≥ 36), representing the functional (6 items), interactive (2 items), and critical (4 items) food literacy dimensions.

2.4. Ethical considerations

The study was performed based on the ethical standards laid down in the Helsinki Declaration. We obtained written approval from the Ethics Committee of Al Zahraa University Medical Center (ZhU#17, 2022), Beirut, Lebanon, and the universities from all participating countries. A consent form was added to the survey, informing participants about their, rights and confidentiality. The participation was entirely voluntary with no obligation to do so.

2.5. Statistical analysis

We performed the statistical analysis using the Statistical Package of Social Sciences Software (SPSS) (Version 25.0. IBM Corp: Armonk, NY, USA). A "weighting" variable was created to adjust the representation of the sampled population. Respondents' characteristics were presented as frequencies (percentages) for categorical variables, while means ± standard deviation (SD) for continuous variables. The adolescence stages were classified as follows: early adolescence (10–13 years old), middle adolescence (14–16 years old), and late adolescence (17–19 years old). The normality of data was checked using the Shapiro–Wilk test. Due to the non-normal distribution, Kruskal-Wallis test was used to determine score differences according to country. Chi-squared test ($\chi 2$) was used to determine associations between study variables. In addition, the binary backward stepwise regression was used to examine the predictors of adolescents' nutrition literacy. A value of p of 5% was considered significant.

3. Results

3.1. General characteristics of adolescents and their parents, overall and by gender

A total of 5,401 adolescent-parent dyads participated in this study. Table 1 shows the general characteristics of participants. Regarding the nationality, 11% were from Lebanon, 9.4% from Bahrain, 12.2% from Egypt, 10.4% from Jordan, 8.9% from Kuwait, 10.9% from Morocco, 9.6% from Palestine, 10.2% from Qatar, 9.1% from Saudi Arabia, and 8.3% from UAE.

Among adolescents, 53.2% were males. The mean age ± SD of the adolescents was 15.9 ± 3.0. Moreover, 51% were in the late adolescence stage, whereas the remaining were either in the early (25%) or the middle (24%) adolescence stage, $p < 0.001$. Around 65% were of normal weight, 27% were overweight, 5% were underweight, and 3% were obese. In addition, 68.5 and 31% were school and university students, respectively. Also, 86% of the adolescents reported both parents as primary caregivers. Around 11.5% were currently working. About 76% were not receiving nutrition education as a part of their schools' curriculum (Table 1). The highest proportion of adolescents who reported not receiving nutrition education was from Morocco (98%), followed by Lebanon (85%) andKuwait (85%), (Figure 1). Furthermore, 81% of adolescents attending public schools reported not receiving nutrition education, in contrast to 67% of those who were private school students, $p < 0.001$ (Figure 1).

As for the parent participants, 67.8% were mothers with a mean age ± SD of 43.0 ± 8.0. More than third of parents were overweight (fathers: 38.5%; mothers: 38.2%, $p < 0.001$). where39% of parents had no job, and half of themhad health problems (Table 1).

3.2. The level of adolescents' nutrition literacy and the food literacy of their parents, overall and by country

In the overall adolescent population, the mean TNL score was 70.6 ± 9.5, with poor nutrition literacy was found in 28% of adolescents. The FNL, INL, and CNL scores were as follows: 22.7 ± 7, 18.5 ± 5.8, and 29.5 ± 4.6, respectively. Hence, 4 out of 10 adolescents (36%) were with poor FNL and INL, and 21% were with poor CNL (Table 2).

TABLE 1 General characteristics of adolescents, overall and by gender.

Variables	Overall (N=5,401)		Male (n=2,872; 53.2%)		Female (n=2,529; 46.8%)		Value of p
Adolescent Participant	Mean±SD		Mean±SD		Mean±SD		
Age (Year)	15.9 ± 3.0		15.0 ± 3.0		16.0 ± 3.0		<0.001
	N	%	*n*	%	*n*	%	
Adolescence stage							<0.001
Early adolescence (10–13 years old)	1,354	25.1	898	31.3	456	18.0	
Middle adolescence (14–16 years old)	1,299	24.0	742	25.8	557	22.0	
Late adolescence (17–19 years old)	2,748	50.9	1,232	42.9	1,516	59.9	
Country of nationality							<0.001
Lebanon	594	11.0	374	13.0	220	8.7	
Bahrain	507	9.4	232	8.1	274	10.9	
Egypt	657	12.2	477	16.6	180	7.1	
Jordan	563	10.4	325	11.3	239	9.4	
Kuwait	483	8.9	195	6.8	288	11.4	
Morocco	590	10.9	377	13.1	212	8.4	
Palestine	517	9.6	251	8.7	267	10.5	
Qatar	549	10.2	298	10.4	251	9.9	
Saudi Arabia	491	9.1	206	7.2	285	11.3	
United Arab Emirates	450	8.3	137	4.8	313	12.4	
Weight status (n=5,364)							<0.001
Underweight	263	4.9	98	3.4	165	6.4	
Normal-weight	3,471	64.7	1863	65.3	1,608	64.0	
Overweight	1,451	27.0	771	27.0	680	27.0	
Obese	179	3.4	120	4.2	59	2.2	
Education level							<0.001
Not attending school	19	0.3	5	0.2	14	0.6	
Elementary school level	752	13.9	506	17.6	246	9.7	
Intermediate school level	1,133	21.0	692	24.1	441	17.5	
Secondary school level	1816	33.6	1,030	35.9	786	31.1	
University level	1,681	31.1	639	22.2	1,042	41.2	
Primary caregiver							<0.001
Both parents	4,650	86.1	2,472	86.1	2,178	86.1	
Father only	143	2.6	86	3.0	57	2.3	
Mother only	447	8.3	260	9.1	187	7.4	
Others	147	2.7	49	1.7	98	3.9	
None (living alone)	14	0.3	5	0.2	9	0.4	
Currently working							<0.001
No	4,782	88.5	2,478	86.3	2,304	91.1	
Yes	619	11.5	394	13.7	225	8.9	
Education level of mother							<0.001
Never attend school	331	6.1	194	6.8	136	5.4	
Elementary school level	398	7.4	201	7.0	197	7.8	
Intermediate school level	453	8.4	251	8.7	202	8.0	
Secondary school level	1,237	22.9	533	18.6	704	27.8	
University level	2,982	55.2	1,693	58.9	1,290	51.0	

(Continued)

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TABLE 1 (Continued)

Variables	Overall (*N*=5,401)		Male (*n*=2,872; 53.2%)		Female (*n*=2,529; 46.8%)		Value of *p*
Adolescent Participant	Mean±SD		Mean±SD		Mean±SD		
Education level of father							<0.001
Never attend school	219	4.0	131	4.6	88	3.5	
Elementary school level	340	6.3	178	6.2	162	6.4	
Intermediate school level	519	9.6	274	9.6	245	9.7	
Secondary school level	1,287	23.8	617	21.5	670	26.5	
University level	3,036	56.2	1,672	58.2	1,364	54.0	
School type (*n* = 3,699; adolescents currently attending schools)							<0.001
Public school	2,294	62.0	1,261	56.6	1,033	70.2	
Private school	1,405	38.0	966	43.4	439	29.8	
Inclusion of nutrition education in schools' curriculum (*n* = 3,699; adolescents currently attending schools)							<0.001
Yes	903	24.4	484	21.8	419	28.4	
No	2,796	75.6	1742	78.2	1,054	71.6	

As per country, Qatar and Lebanon showed the highest proportions of adolescents with poor TNL (44 and 37.4%, respectively), followed by Saudi Arabia (35%), Bahrain (29.4%), Kuwait (28%), Palestine (25%), Morocco (24%), Jordan (23%), UAE (18.2%), and Egypt (18.1%), $p < 0.001$ (Figure 2). Half the Egyptian adolescents (49.6%) were with poor FNL, followed by Qatari (41.7%) and Lebanese (39.4%) adolescents, $p < 0.001$ (Table 3). Adolescents participants with poor INL were mostly from Qatar (51%), followed by Lebanon (46%) and Bahrain (44.2%), $p < 0.001$ (Table 3). Similarly, around 3 out of 10 Saudi adolescents (29.4%) showed poor CNL, followed by Bahrain (24.2%) and Qatar (23.8%) $p < 0.001$ (Table 3). Regarding parents' food literacy, an overall mean score of 32.8 ± 8.5 was reported, with 60% of parents were found with poor food literacy. Parents from Morocco (77%), Lebanon (71%), and Saudi Arabia (64%) were mostly food illiterate, followed by Qatar (59%), Jordan (58.7%), Palestine (55.3%), Kuwait (54.6%), UAE (52%), Bahrain (45.2%), and Egypt (42.7%), $p < 0.001$ (Table 3).

3.3. The correlates of adolescents' nutrition literacy in the overall sample population

Supplementary Table S1 shows the determinants of adolescents' nutrition literacy. Most older adolescents (77.6%) had adequate TNL, compared to 63.6 and 68.2% of those in the young and middle stages respectively, $p < 0.001$. Similarly, FNL, INL, and CNL, were adequate among older adolescents compared to young and middle stage adolescents (72.5, 66.5, and 80%, respectively, all value of *p*s <0.001). In terms of adolescents' gender, poor nutrition literacy was found significantly more among males compared to females; TNL (32.2% vs. 23.5%, $p < 0.001$), FNL (40.3% vs., 30.3%, $p < 0.001$), and INL (37.8% vs. 34%, $p = 0.003$), respectively. Poor nutrition literacy was also found more among obese adolescents; TNL (35.4%), FNL (43%), and INL (41.3%), although these findings were not significant ($p = 0.17$, $p = 0.09$, and $p = 0.06$, respectively). Parents who were underweight and with obesity had more adolescents with poor TNL (38 and 31.6%, respectively), compared to normal-weight and overweight parents (26.7 and 26.5%, respectively) $p < 0.001$. Further, it was noted that nearly half the obese parents (41.2%) had adolescent with poor FNL, $p < 0.001$. On the other hand, adequate level of nutrition literacy scores was found more among adolescents studying at university, with TNL (81%, $p < 0.001$), FNL (75%, $p < 0.001$), INL (68.7%, $p < 0.001$), and CNL (81%, $p = 0.002$), compared to those at school level (67.8, 59.5, 62, and 78.8%, respectively), and those not attending a school or university (50, 66.7%. 47.4, and 52.6%, respectively) (Supplementary Table S1).

Mothers with university degree had predominately adolescent with adequate INL (67%, $p < 0.001$) and CNL (81.6%, $p < 0.001$). Similarly, adolescents of fathers having university degree showed adequate TNL (72.2%, $p = 0.012$), FNL (63.5%, $p = 0.008$), INL (67%, $p < 0.001$), and CNL (80.4%, $p < 0.001$). In addition, adolescents having both parents as primary caregivers expressed adequate TNL (68.6%, $p < 0.001$), INL (58.8%, $p = 0.03$), and CNL (61.3%, $p < 0.001$). Moreover, working adolescents had predominately adequate TNL (79.8% vs. 70.8%, $p < 0.001$) and FNL (68.4% vs. 61.6%, $p = 0.03$), compared to non-workers. However, the school type was not a significant correlate except in the FNL, with adolescents in private schools scoring better in FNL compared to those in public schools (66% vs. 64.3%, $p < 0.001$). Adolescents receiving nutrition education showed significantly better TNL and INL in contrast to others who did not report so (73.6% vs. 65.9%, $p < 0.001$) and (68.5% vs. 59.8%, $p < 0.001$), respectively. Most married parents had adolescent with adequate TNL (68.6%, $p < 0.001$), INL (61.5%, $p < 0.001$), and CNL (79.4%, $p < 0.001$). Moreover, parents having 2–3 children had a higher proportion of adolescent with adequate TNL (69.4%, $p = 0.015$), INL (65%, $p < 0.001$), and CNL (82%, $p < 0.001$). Around 36% of parents with reported disease (vs. 18%

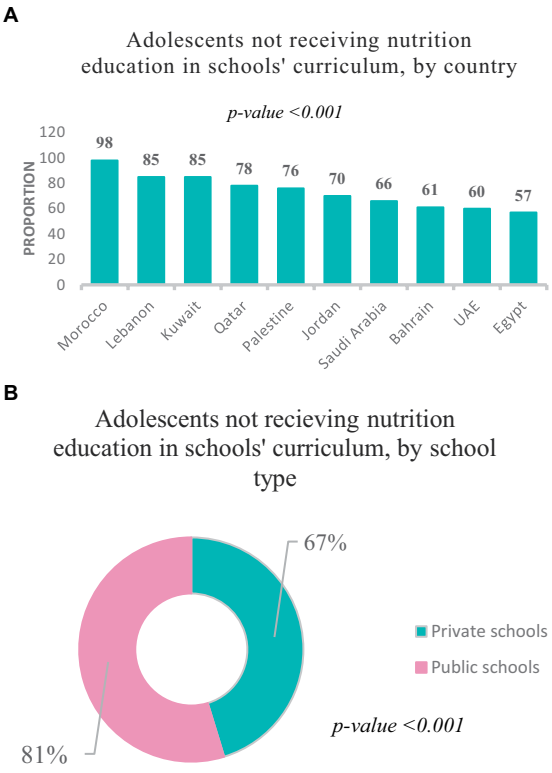

FIGURE 1
(A) Adolescents not receiving nutrition education in schools' curriculum, by country (n=3,699 school attendees). **(B)** Adolescents not receiving nutrition education in schools' curriculum, by school type (n=3,699 school attendees).

healthy) had adolescent with poor TNL, $p=0.017$. As well, a higher proportion of food illiterate parents (vs. food literate) had adolescent who were nutritionally illiterate too, in TNL (36.6% vs. 25.8%, $p<0.001$) INL (45.2% vs. 27.5%, $p<0.001$) and CNL (25.3% vs. 15%, $p<0.001$) dimensions (Supplementary Table S1).

3.4. Predictors of the adolescents' nutrition literacy in this study

Table 4 shows the significant predictors of adolescents' nutrition literacy. Older adolescents (vs. younger adolescents) were 1.6 times (OR=1.6, CI=1.4–1.9, $p<0.001$) more likely to be nutritionally literate. Female adolescents had a 30% more probability of having adequate nutrition literacy (vs. males OR=0.7, CI=0.6–0.8, $p<0.001$). Besides, adolescents who were university students (OR=4.5, CI=1.8–11.5, $p=0.001$) were 4.5 times more likely to be nutritionally literate. Adolescents with parents who were either overweight or obese were 1.5 times more likely to be with adequate nutrition literacy (OR=1.5, CI=1.0–2.2, $p=0.04$). Further, adolescents with both parents as primary caregivers (vs. either parent and others, OR=0.7, C I=0.6–0.8, $p<0.001$, and OR=0.7, CI=0.5–1, $p=0.03$, respectively) were 30, and 60% (vs. living alone, OR=0.4, CI=0.1, 1.1, $p=0.001$) more likely to be nutritionally literate. Furthermore, working adolescents were 1.5 times more likely to have adequate nutrition literacy (OR=1.5, CI=1.2–1.8, 0.001). Parents with one child (vs. ≥ 3 children) were 30% more likely to be with adequate nutrition literacy (OR=0.7, CI=0.5–0.9, $p<0.001$). Adolescents receiving nutrition education were 30% more likely to be nutritionally literate (OR=1.3, CI=1.1–1.5, $p=0.01$). Parents who reported to be healthy were 20% more likely to have adolescent who are nutritionally literate (OR=1.2, CI=1.0–1.4, $p=0.01$). In addition, food literate parents were 2 times more likely to have nutritionally literate adolescent (OR=1.8, CI=1.6–2.1, $p<0.001$) (Table 4).

4. Discussion

This study assessed the Arab adolescents' nutrition literacy and the food literacy of their parents. About 28% of adolescents had poor nutrition literacy, with 60% of their parents being food "less literate." Nutrition illiteracy was most prevalent in Qatar (44%), Lebanon (37.4%), and Saudi Arabia (34.9%). Adolescents' age, gender, education level, primary caregiving, employment status, and receiving nutrition education in schools predicted their nutrition literacy levels. Besides, parental weight status, health status, parent food literacy level, and the number of children per household were significant determinants.

There is scarcity of studies evaluating nutrition literacy among the Arab population. All in all, only three studies on this topic were conducted and were chiefly in Lebanon and Palestine (16, 23, 24). Our study findings are in concordance with that previously reported in Lebanon which highlight inadequate nutrition literacy status among adolescents (23), but in high contrast to that observed among Palestinian adults (75% were nutritionally illiterate) (24). Apart from the Arab region, our observed mean score ± SD of nutrition literacy (70.6 ± 9.5) is quite close to that reported among a study in China (61.7 ± 14.37) (25) and 3 studies in Turkey (67.6 ± 7.9; 72.3 ± 8.2; 70.31 ± 8.6) (17, 26, 27). In the present study, Qatari adolescents pose an added risk of nutrition illiteracy (44%). A review of studies in Qatar shows that the high gross domestic product has led to the adoption of western lifestyles in the country, promoting childhood overweight and obesity (28). Besides, the highest levels of obesity among Arab countries were observed in Bahrain, Kuwait, Qatar, and UAE (29). Nutrition literacy is a critical influencing factor of obesity, with a higher literacy level associated with appropriate dietary habits and food-related behaviors (30). Lebanon, on the other hand, ranked second in the present study for adolescent nutrition illiteracy. Between 1997 and 2009, significant changes were observed in the diet of the Lebanese population, with high intakes of salty snacks, added fats, and oils (31). This dietary transition, along with the increase in sedentary behaviors, poor nutrition knowledge, and the economic collapse, has put Lebanon at risk of further constraints in terms of malnutrition prevalence (31). In this context, our study shows that 75.6% of adolescents do not receive nutrition education in schools. Further, nutrition education was mostly provided for Egyptian adolescents who were mostly nutritionally literate. Hence, the latter finding reemphasize the relevance of nutrition education in improving students' nutrition literacy. In this regard, several school-based nutrition education programs

TABLE 2 General characteristics of parents, overall and by gender.

Parent participant	Overall (*n*=5,401)		Father (*n*=1739; 32.2%)		Mother (*n*=3,661; 67.8%)		Value of *p*
	Mean±SD		Mean±SD		Mean±SD		
Age: (Year)	45 ± 9.1		49 ± 10		43 ± 8		<0.001
	n	%	*n*	%	*n*	%	
Country of nationality							<0.001
Lebanon	594	11.0	201	11.6	392	10.7	
Bahrain	507	9.4	181	10.4	326	8.9	
Egypt	657	12.2	125	7.2	532	14.5	
Jordan	563	10.4	187	10.8	376	10.3	
Kuwait	483	8.9	98	5.6	385	10.5	
Morocco	590	10.9	379	21.8	210	5.7	
Palestine	517	9.6	142	8.2	375	10.2	
Qatar	549	10.2	135	7.8	414	11.3	
Saudi Arabia	491	9.1	136	7.8	355	9.7	
United Arab Emirates	450	8.3	154	8.9	296	8.1	
Weight status							<0.001
Underweight	121	2.2	47	2.7	74	2.0	
Normal-weight	1789	33.1	668	38.4	1,121	30.6	
Overweight	2069	38.3	670	38.5	1,399	38.2	
Obese	1,422	26.3	355	20.4	1,067	29.2	
Marital status							0.002
Married	4,885	90.5	1,605	92.3	3,280	89.6	
Divorced	284	5.2	65	3.8	218	218	
Widowed	232	4.3	69	4.0	163	163	
Number of children							<0.001
1	508	9.4	178	10.3	329	9.0	
2–3	2,790	51.7	974	56.0	1816	49.6	
>3	2,103	38.9	587	33.7	1,516	41.4	
Education level							<0.001
Never attend school	234	4.3	96	5.5	138	3.8	
Elementary school level	302	5.6	144	8.3	158	4.3	
Intermediate school level	355	6.6	113	6.5	242	6.6	
Secondary school level	1,198	22.2	410	23.6	788	21.5	
University level	3,312	61.3	976	56.1	2,336	63.8	
Spouses' education level							<0.001
Never attend school	325	6.0	218	12.5	107	2.9	
Elementary school level	347	6.4	172	9.9	175	4.8	
Intermediate school level	383	7.1	111	6.4	272	7.4	
Secondary school level	1,244	23.0	407	23.4	836	22.8	
University level	3,102	57.4	831	47.8	2,271	62.0	
Job status							<0.001
No job	2,117	39.2	295	16.9	1822	49.7	
Full-time job	1851	34.3	820	47.2	1,031	28.2	
Part-time job	532	9.9	195	11.2	337	9.2	
Self-employed	901	16.7	429	24.7	472	12.9	

(Continued)

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TABLE 2 (Continued)

Parent participant	Overall (*n*=5,401)		Father (*n*=1739; 32.2%)		Mother (*n*=3,661; 67.8%)		Value of *p*
	Mean±SD		Mean±SD		Mean±SD		
Prevalence of chronic diseases (*N* = 2,776 diseased parents; *n* males = 942; *n* females = 1834)							
Cardiovascular diseases (CVD)	230	8.3	90	9.5	140	7.6	0.02
Diabetes	603	21.7	264	28.0	339	18.5	<0.001
Hypertension	693	25.0	303	32.2	390	21.3	<0.001
Chronic kidney diseases (CKD)	91	3.3	36	3.8	55	3.0	0.13
Liver diseases	69	2.4	31	3.3	38	2.1	0.03
Osteoporosis	125	4.5	22	2.3	103	5.6	<0.001
Cancer	39	1.4	10	1.1	29	1.6	0.26
Respiratory diseases	199	7.2	65	7.0	134	7.3	0.89
Anemia	494	17.8	79	8.4	415	22.6	<0.001
Others	233	8.4	42	4.4	191	10.4	<0.001
Household crowding index*							
≤1[a]	3,196	59.2	–	–	–	–	–
>1[b]	1,011	18.7	–	–	–	–	–
>1.5[c]	1,194	22.1	–	–	–	–	–

*Number of co-residents (excluding newborns) divided by number of rooms (excluding kitchens and bathrooms). [a]No crowding. [b]Crowded. [c]Over-crowded.

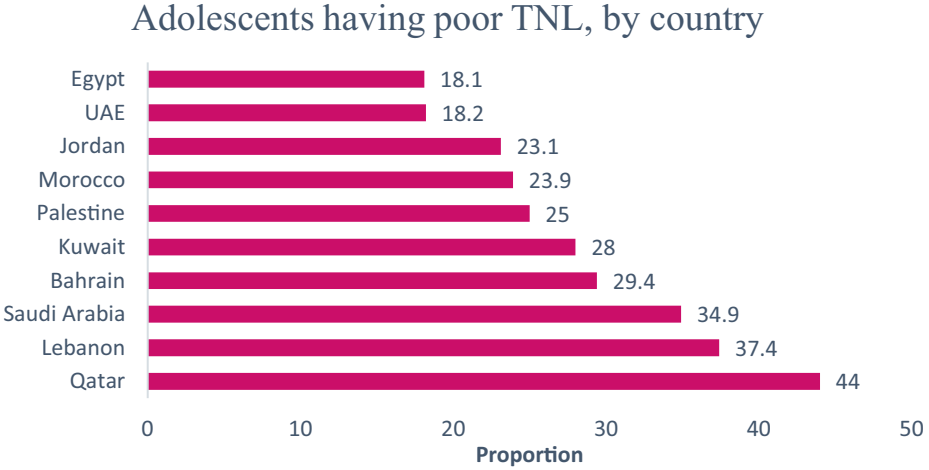

FIGURE 2
The proportion of adolescents having poor total nutrition literacy (TNL), by country.

have shown effectiveness in promoting nutrition knowledge, healthy dietary habits, and self-efficacy among students (32–35). Therefore, such interventions are indispensable in the Arab region where malnutrition prevalence is of mounting concern. In addition to classroom approaches, farm-to-school programs, school gardens, and cooking programs might be also prioritized (19). In this study, adolescents of older age reported better nutrition literacy levels than younger ones. Variations in nutrition literacy levels among adolescence age could be due to increased exposure to and interest in health-related information with advancing age (36). Furtherly, female adolescents were more nutritionally literate than males. This is consistent with data from Turkey (17, 27) and Iran (15, 37). One possible explanation for gender disparities is that females focus on the nutritional value of food and prioritize healthy eating more than men (38). Women have better nutrition knowledge, and recognize nutrition as a critical contributor to their conception of health (39). Furthermore, higher education levels determined better

TABLE 3 The level of adolescents' nutrition literacy and the food literacy of their parents, overall and by country.

	Overall (*N*=5,401)	Lebanon (*n*=594)	Bahrain (*n*=507)	Egypt (*n*=657)	Jordan (*n*=563)	Kuwait (*n*=483)	Morocco (*n*=590)	Palestine (*n*=517)	Qatar (*n*=549)	Saudi Arabia (*n*=491)	UAE (*n*=450)	Value of *p*
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	
Adolescent: TNL[a]												
TNL score (Mean ± SD)	70.6 ± 9.5	69 ± 11	71 ± 11	68 ± 5	71 ± 8	72 ± 10	72 ± 10	72 ± 9	68 ± 9	70 ± 9	74 ± 10	<0.001*
Poor	1,514 (28.0)	222 (37.4)	150 (29.4)	119 (18.1)	130 (23.1)	135 (28.0)	141 (23.9)	130 (25.1)	242 (44.0)	171 (34.9)	82 (18.2)	<0.001**
Adequate	3,887 (72.0)	372 (62.6)	357 (70.6)	538 (81.9)	433 (76.9)	348 (72.0)	449 (76.1)	387 (74.9)	307 (56.0)	320 (65.1)	368 (81.8)	
Adolescent: FNL[b]												
FNL score (Mean ± SD)	22.7 ± 7	22.2 ± 6.7	24.9 ± 6.7	19 ± 7.7	23.1 ± 5.7	6.18 ± 22.3	22.4 ± 5.4	23.5 ± 6.7	22.3 ± 7.4	23.8 ± 7.1	25.3 ± 6.75	<0.001*
Poor	1919 (36)	234 (39.4)	139 (27.4)	326 (49.6)	173 (30.8)	191 (39.4)	209 (35.5)	154 (29.8)	229 (41.7)	159 (32.5)	110 (24.4)	<0.001**
Adequate	3,482 (64)	360 (60.6)	368 (72.6)	331 (50.4)	390 (69.2)	292 (60.6)	381 (64.5)	363 (70.2)	320 (58.3)	332 (67.5)	340 (75.6)	
Adolescent: INL[c]												
INL score (Mean ± SD)	18.45 ± 5.8	18 ± 6	18 ± 6	20 ± 6	19 ± 5	19 ± 6	19 ± 4	19 ± 6	17 ± 6	17 ± 6	19 ± 6	<0.001*
Poor	1944 (36.0)	273 (46.0)	224 (44.2)	88 (13.3)	165 (29.4)	166 (34.4)	200 (33.8)	185 (35.9)	279 (51.1)	210 (42.8)	153 (33.9)	<0.001**
Adequate	3,457 (64.0)	321 (54.0)	283 (55.8)	569 (86.7)	398 (70.6)	317 (65.6)	390 (66.2)	332 (64.1)	268 (48.9)	281 (57.2)	297 (66.1)	
Adolescent: CNL[d]												
CNL score (Mean ± SD)	29.46 ± 4.62	29 ± 5	29 ± 4	29 ± 4	29 ± 4	30 ± 4	31 ± 6	29 ± 4	29 ± 4	29 ± 5	30 ± 4	<0.001**
Poor	1,112 (20.6)	135 (22.6)	123 (24.2)	77 (11.7)	132 (23.5)	79 (16.3)	110 (18.7)	117 (22.8)	131 (23.8)	144 (29.4)	66 (14.6)	
Adequate	4,289 (79.4)	459 (77.4)	384 (75.8)	580 (88.3)	431 (76.5)	404 (83.7)	480 (81.3)	400 (77.2)	418 (76.2)	347 (70.6)	384 (85.4)	
Parent: FL[e]												
FL score (Mean ± SD)	32.8 ± 8.5	31 ± 9	35 ± 8	35 ± 9	32 ± 8	34 ± 7	29 ± 8	32 ± 9	33 ± 9	32 ± 8	35 ± 6	<0.001*
Poor	2,208 (59.7)	330 (70.8)	105 (45.2)	209 (42.7)	201 (58.7)	172 (54.6)	452 (77.0)	150 (55.3)	242 (59.0)	226 (63.8)	120 (52.2)	<0.001**
Adequate	1,492 (40.3)	138 (29.2)	128 (54.8)	281 (57.3)	142 (41.3)	143 (45.4)	135 (23.0)	121 (44.7)	168 (41.0)	128 (36.2)	110 (47.8)	

[a]Total Nutrition Literacy. [b]Functional Nutrition Literacy. [c]Interactive Nutrition Literacy. [d]Critical Nutrition Literacy. [e]Food Literacy.

*Significant at value of $p < 0.05$ of Kruskal-Wallis test.

**Significant at value of $p < 0.05$ of $\chi 2$ test.

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TABLE 4 Predictors factors of adolescents' nutrition literacy.

Binary logistic regression taking the total nutrition literacy (TNL) [poor (reference) vs. adequate] as the dependent variable	AOR (95% CI)	Value of *p*
Adolescence stage reference: Early (10–13 years old)	–	–
Middle (14–16 years old)	1.3 (1.1–1.5)	0.003
Late (17–19 years old)	1.6 (1.4–1.9)	<0.001
Gender (adolescent) reference: Females	–	–
Males	0.7 (0.6–0.8)	<0.001
Adolescent education level (Reference: Not attending school or university)		
University level	4.5 (1.8–11.5)	0.001
Parental weight status reference: Underweight	–	–
Overweight/Obese	1.5 (1.0–2.2)	0.04
Primary caregiver (Reference: Both parents)		
Either parent	0.7 (0.6–0.8)	<0.001
Others	0.7 (0.5–1.0)	0.03
None (living alone)	0.4 (0.1–1.1)	0.001
The adolescent is currently working (Reference: No)		
Yes	1.5 (1.2–1.8)	0.001
Number of children in the household (Reference: One child)		
2–3 children	0.9 (0.7–1.1)	0.37
More than 3	0.7 (0.5–0.9)	0.001
The adolescent is receiving nutrition education in their schools' curriculum (Reference: No)		
Yes	1.3 (1.1–1.5)	0.01
Parent has one or more chronic disease (Reference: Yes)		
No	1.2 (1.0–1.4)	0.01
Parental food literacy (Reference: Poor)		
Adequate	1.8 (1.6–2.1)	<0.001

adolescents' nutrition literacy in our study, which is consistent with data from China (25) and Italy (40). Individuals with the highest education level have a better ability to understand, process, and apply nutrition information. Our findings also showed that working adolescents had better nutrition literacy than their counterparts. We believe that adolescent workers are most likely employed in surroundings that promote health and nutrition. In addition, adolescents having both parents as primary caregivers had the most adequate nutrition literacy, which goes hand in hand with findings from China (25). Above all, obese and overweight parents had more nutritionally illiterate adolescent than their counterparts. Obesity among parents might drive their children to attain more nutrition information to help them change their dietary habits and lose or maintain body weight. Diseased parents in the current study had mostly nutritionally illiterate adolescent. These findings suggest that the occurrence of nutrition-related diseases among parents, which usually correlates with unhealthy diets and lack nutrition knowledge, may negatively affect their children's nutrition literacy. Moreover, food literate parents had mostly nutritionally literate adolescent. This finding is supported by those reported in Greece (41) and the United States (42), where parental nutrition literacy was positively correlated with healthy parental feeding practices (PFP), and child Healthy Eating Index (HEI). Food literate parents are more likely to engage their children in nutrition communication and expose them to reliable information sources about nutrition from professionals (43). Our data may be useful reference for policymakers and curriculum developers to assess education and develop practical learning and teaching strategies to improve student's food and nutrition literacy as indicated in a recent systematic review (44).

4.1. Limits and strengths

The current study had some limitations that should be acknowledged. First, due to the unavailability of valid questionnaires regarding nutrition and food literacy in the region, the questionnaires in this study were derived from many credible, valid sources and translated to Arabic then back translated to English by experts. Second, due to its cross-sectional design, causal inferences cannot be drawn. Third, the self-administered questionnaire causes inevitable information bias. Fourth, convenience sampling could lead to skewed sample characteristics. Fifth, we collected no information on adolescents' food habits which most probably correlate with nutrition literacy. Nonetheless, this study is the first of the region's kind, with a large sample of Arab adolescents and their parents addressing the nutrition and food literacy topics.

5. Conclusion

This study shows that nutrition literacy inadequacy among Arab adolescents is a prioritized challenge to be addressed. The "macro-curriculum" concept in schools includes intervention packages to implement, leading to the best possible nutrition outcomes. The target group for interventions includes school-age children, teachers at both public and private institutions, as well as the ministries of education and health in each Arab nation. Classroom activities, such as counting with pictures of fruits and vegetables, learning about cultural food traditions, and measuring ingredients for a recipe, could be included in school interventions. Additionally, schools can send daily messages with nutrition content, such as morning announcements, to other family members. Staff meetings, parent-teacher interviews, and home cooking activities are also things to be considered.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Al Zahraa University Medical Center (ZhU#17, 2022), Beirut, Lebanon, and the universities from all participating countries. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

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Author contributions

MH: conceptualization, validation, and project administration. HM, KB, FH, SA, DA, HA, HB, IK, RQ, and RT: methodology. RQ: software. HM: formal analysis. MH and HM: data curation and writing—original draft preparation. All authors: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Dietary profile of pediatric obstructive sleep apnea patients, effects of routine educational counseling, and predictors for outcomes

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Background: Dietary behavior is a main contributing yet modifiable factor to the body weight status of children and may be involved in the pathophysiology of childhood obstructive sleep apnea (OSA). This study aimed to investigate the dietary profile of pediatric OSA patients, effects of educational counseling after adenotonsillectomy, and predictor for disease resolution.

Methods: This observational study included 50 pediatric OSA patients undergoing adenotonsillectomy with routine educational counseling (Group 1), 50 pediatric OSA patients undergoing adenotonsillectomy without formal educational counseling (Group 2), and 303 healthy children without OSA (Control). The three groups were matched by age. The consumption frequency of 25 food items/groups was assessed by the Short Food Frequency Questionnaire. Quality of life was evaluated by the OSA-18 questionnaire. Sleep architecture and OSA severity were measured by standard polysomnography. Between- and within-group comparisons were analyzed by non-parametric approaches and generalized estimating equations. Prediction of disease recovery was performed by multivariable logistic regression models.

Results: Group 1 children consumed fruit drinks with sugar, vegetables, sweets, chocolate, rice, and noodles more frequently than Control Group children. At baseline, the distributions of sex, weight status, OSA-18 scores, and polysomnographic variables were comparable between Group 1 and Group 2. After a 12-month follow-up, Group 1 had better improvements in physical suffering, caregiver concerns, sleep architecture, and mean peripheral oxygen saturation compared to Group 2. Furthermore, Group 1 no longer had excessive

consumption of fruit drinks with sugar, chocolate, and noodles; however, food consumption frequencies did not change significantly. Notably, younger age and reduced intake of butter/margarine on bread and noodles were independent predictors of cured OSA in Group 1.

Conclusion: The present study preliminarily characterized an unhealthy dietary profile among pediatric OSA patients and suggested that routine educational counseling in addition to adenotonsillectomy yielded some clinical benefits. Certain items/groups of food frequencies may be associated with disease recovery and further investigations are warranted.

KEYWORDS

adenotonsillectomy, children, dietary profile, dietary educational counseling, food frequency, food literacy, obstructive sleep apnea, outcome assessment

1. Introduction

Obstructive sleep apnea (OSA) is one of the most common sleep disorders in children, with a prevalence of approximately 4% worldwide (1). In addition to snoring and abnormal breathing during sleep, childhood OSA can be comorbid with many diseases, such as obesity (2), metabolic syndrome (3), cardiovascular disease (4), and attention-deficit/hyperactivity disorder (5). Hypertrophy of the adenoid and tonsils and overweight/obesity are frequently encountered in pediatric OSA patients (6–8). Adenotonsillectomy remains the first-line treatment for childhood OSA (6, 9). However, residual OSA after adenotonsillectomy (defined by a postoperative apnea-hypopnea index [AHI] $\geq$ 1.0 events/h) is not uncommon, accounting for 49% of the overall adenotonsillectomy-treated pediatric OSA patients and 66% of those with obesity (10). Furthermore, age and obesity are two well-recognized risk factors for residual disease after adenotonsillectomy among pediatric OSA patients (8, 11, 12). Although residual OSA does not necessarily represent a treatment failure, efforts are underway to identify successful strategies for curing OSA.

Evidence has indicated negative impacts of inadequate or poor-qualitied sleep on weight status and metabolic prolife (13–15). Preadolescents with longer sleep duration had lower body fat percentage and better insulin sensitivity (16). Sleep restriction increases levels of ghrelin, the "hunger hormone" which promotes appetite and stimulates eating (17). Food intake following sleep restriction contains an average of 328 more calories, primarily from carbohydrates (17). Sleep duration reduction, poor sleep quality, and circadian rhythm dysregulation can all lead to insulin resistance, a cardinal pathway to the development of metabolic syndrome and type 2 diabetes (18). Some study also suggests that lack of sleep has a direct negative effect on physical activity (19). Despite still some knowledge gap in pathophysiology, it has been quite evident that insufficient or bad sleep leads to weight gain and metabolic deterioration.

Intriguingly, albeit a significant improvement in sleep quality, pediatric OSA patients are likely to increase their body mass index (BMI) z-score (20) after adenotonsillectomy. Furthermore, the velocity and amount of weight gain in turn becomes independent risk factors for OSA recurrence in children (21). Some specific foods have been associated with excessive weight gain among children and adolescents, such as butter/margarine spread, potato chips, coated fish, processed meats, desserts and sweets, milk, and savory snacks (22). Increases in caloric and protein intake also have been linked to somatic growth in this population (20). Multidisciplinary weight loss interventions have been shown to improve the severity of OSA in children and adolescents with obesity (23). However, the relationships between OSA and eating behavior remain unclear in adults (24), and data for pediatric OSA patients are even scantier (25). Evidence on the effectiveness of educational counseling is lacking. The associations of baseline characters or changes in dietary behavior with OSA treatment outcomes are unknown.

We hypothesized that pediatric OSA patients were more prone to unhealthy eating, and educational counseling would have positive effects on their dietary behavior and clinical health outcomes; furthermore, changes in eating were causally attributable to changes in subjective and objective sleep parameters after adenotonsillectomy. This study aimed to: (1) delineate the dietary profile of pediatric OSA patients and compare it to children without OSA, (2) investigate the effects of educational counseling on food consumption and sleep outcomes among pediatric OSA patients undergoing adenotonsillectomy, and (3) identify predictors for cured OSA in patients receiving combined treatment.

2. Materials and methods

2.1. Study participants

The retrospective case–controlled study retrieved data from our previously established databank (26), a collection of electronic medical records of 396 children who were referred to the Department of Otorhinolaryngology-Head and Neck Surgery at Chang Gung Memorial Hospital (Linkou Main Branch, Taoyuan, Taiwan) to treat OSA between January 2010 and August 2019. This retrospective study was approved by the Institutional Review Board of Chang Gung Medical Foundation (No. 202000873B0). The requirement for written informed consent had been waived because the subsequent analyses were based on existing data. All procedures complied with the Declaration of Helsinki 1975, and the Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology guidelines were followed (27). Parts of the subjects' characteristics have also been reported elsewhere (7, 8, 28–31).

The inclusion criteria of this study were: (1) age 5–12 years, (2) available polysomnography confirming the diagnosis of OSA based on the definition of obstructive AHI ≥ 2.0 events/h or obstructive apnea index ≥1.0 event/h (8, 32), and (3) a history of adenotonsillectomy at our department during the study period. The exclusion criteria were: (1) patients with craniofacial, neuromuscular, or chronic inflammatory disorders that required multi-modality treatments (28, 33), and (2) those with no available data of item/group-specific food frequencies, quality of life, or polysomnographic data at baseline and 6 months post-adenotonsillectomy.

The subjects were further divided into 'Group 1' (adenotonsillectomy with routine educational counseling) and 'Group 2' (adenotonsillectomy without formal educational counseling). Furthermore, Group 1 and Group 2 participants were matched by age, sex, BMI z-score, AHI, and follow-up period.

To compare the dietary profiles of the study participants to the general population, we included data from a prospective internet survey investigating item/group-specific food frequencies among healthy Taiwanese children without obvious OSA symptoms. We invited parents and caregivers who had children without habitual snoring to evaluate their children's food frequencies from November 24, 2022, to November 30, 2022. The inclusion criteria were: (1) age 5–12 years, (2) no obvious OSA symptoms such as habitual snoring, sleep-disturbed breathing, chronic mouth breathing, daytime sleepiness, and attention-deficit/hyperactivity, and (3) total score of the OSA-18 questionnaire <60 (34). The exclusion criteria were: (1) any known history of chronic disorders such as neuromuscular, gastrointestinal, or cardiovascular disorders, and (2) any long-termed usage of medications. All participants filled in the questionnaire voluntarily without any incentive offered. The Institutional Review Board of Chang Gung Medical Foundation approved this internet survey (No. 202201649B0), and the anonymous volunteers (children's parents/caregivers) agreed to participate after reading the informed consent.

2.2. Measurements

2.2.1. Clinical information

Age, sex, tonsil size, adenoidal-nasopharyngeal ratio (ANR), and BMI z-score were recorded. Obesity was defined by a BMI z-score ≥ 1.645 (35). Radical adenotonsillectomy procedures, including extracapsular tonsillectomy and adenoidectomy, were performed by the principal investigators in a single stage under general anesthesia (36). All the children received inpatient care with an average hospitalization of 3 days and ate a regular diet within 2 weeks.

2.2.2. Food frequency

All caregivers recorded the consumption frequency of 23 food items in their children using the Short Food Frequency Questionnaire (SFFQ) (37). Nine questions of the SFFQ pertain to drinks, including full-fat milk, low-fat milk (1.5% fat), semi-skimmed milk (0.7% fat), skimmed milk, orange juice, fruit drinks and soft drinks with or without sugar. The SFFQ also contains questions on each of the following food items or food groups: potatoes, vegetables, fruit/berries, potato chips, whole meal bread, fish for dinner (not including bread spread), pizza, hamburgers/hot dogs/kebabs, sweets, chocolate, savory snacks, peanuts and cod liver oil/vitamin supplements, and an additional question on the use of butter/margarine on bread. In addition, two Chinese food items (rice and noodles) were also investigated in the present study. The participants and their caregivers were asked to recall their food habits in the past 1 month and filled in the questionnaire together. The frequency scale used for drinks was 0 (never-seldom), 1 (1–3 glasses per month), 2 (1–3 glasses per week), 3 (4–6 glasses per week), 4 (1–3 glasses per day), 5 (4–6 glasses per day), and 6 (7 glasses or more per day). Half a liter was defined as being equal to 3 glasses. For other foods, the frequency scales were 0 (never-seldom), 1 (1–3 times per month), 2 (1–3 times per week), 3 (4–6 times per week), 4 (1 time per day), 5 (2 times per day), 6 (3 times per day), and 7 (4 or more times per day). The question about the use of butter/margarine on bread was answered with 1 (yes) or 0 (no). The reproducibility of the 23 food items/groups of the SFFQ ranged from moderate to almost perfect (intraclass correlation coefficients: 0.58–0.84) (38) with moderate test–retest reliability (39). It has been validated to rank children according to food item/group intake (38), dietary behaviors (40, 41), and adherence to dietary guidelines (42).

2.2.3. Quality of life

All caregivers evaluated their children's OSA-related quality of life using the Chinese version of the OSA-18 questionnaire (43), which includes 18 items scored using a 7-point ordinal scale (overall range, 18–126) and has been shown to have excellent test–retest reliability (34). This questionnaire collected information about five domains that are considered to be elements in the quality of life: sleep disturbance (4 items), physical suffering (4 items), emotional distress (3 items), daytime problems (3 items), and caregiver concerns (4 items).

2.2.4. Polysomnography

All participants underwent full-night, in-laboratory polysomnography (Nicolet Biomedical Inc., Madison, WI, United States) to document objective sleep characteristics (33). Total sleep time, sleep stages, AHI, apnea index, arousal index, mean peripheral oxygen saturation (SpO_2), and minimal SpO_2 were scored and manually verified by the study investigators, according to the 2012 American Academy of Sleep Medicine Scoring Manual (44). An apnea episode was defined as a ≥ 90% decrease in airflow for a duration of ≥2 consecutive breaths, and a hypopnea episode was defined as a ≥ 30% decrease in airflow in association with electroencephalographic arousal or a ≥ 3% reduction in SpO_2 for a duration of ≥2 consecutive breaths. The AHI was calculated by dividing the sum of all apneas and hypopneas by the hours of total sleep time. Herein, 'cured OSA' was defined as a reduction in both obstructive AHI < 2.0 events/h and obstructive apnea index <1.0 event/h after adenotonsillectomy and/or educational counseling (32).

2.3. Routine educational counseling

Each child of Group 1, who had been enrolled in our previous study [CMRPG3F1091-3, approved by the Institutional Review Board of Chang Gung Medical Foundation (No. 201507279A3), study period 2016–2019] (8, 28), received three sessions of age-appropriate educational counseling within 3 months after adenotonsillectomy. The children and their caregivers were given verbal recommendations for sleep hygiene (adequate sleep, early sleep, avoid caffeine after

lunchtime, avoid large meals or vigorous physical activity before bedtime), healthy eating [limit sweetened beverages, eat less fast food, recommend the Daily Dietary Guidelines of Taiwan for children as a reference material (45)], regular exercise (increase outdoor/after-school exercise, exercise training), and nasal saline irrigation (46). Each session of educational counseling was conducted face-to-face for 10–15 min by the research investigators and assistants.

2.4. Statistical analysis

Data were analyzed using G*Power 3.1.9.2 (Heinrich-Heine University, Dusseldorf, Germany), SPSS version 25.0 (IBM Corp., Armonk, NY, United States), and GraphPad Prism 9.0 for Windows (Graph Pad Software Inc., San Diego, CA, United States). The Shapiro–Wilk test was used to examine normality, which showed that most of the continuous variables of interest were non-parametric. Therefore, descriptive statistics were expressed as median (interquartile range [IQR]) for continuous and skewed variables and number (proportion) for categorical variables.

Based on a previous study (47), we applied fruit frequency to estimate the sample size. The modal scores of fruit consumption in healthy children without OSA ($n = 177$), pediatric OSA patients without obesity ($n = 25$), and pediatric OSA patients with obesity ($n = 43$) were 3–5 times/week, 3–5 times/week, and 1–2 times/week, respectively (Kruskal-Wallis test of variance by ranks, $H(2245) = 7.0$, $p = 0.03$). To compare the difference between healthy children without OSA and pediatric OSA patients, we estimated the weighted modal score of pediatric OSA patients. To reach 95% power with a type I error of 0.05, the total sample size would be 38. However, the investigation was powered to detect item/group-specific food frequencies as low as 0% reliably; we estimated the absence of item/group-specific food frequencies among 300 children would generate a one-sided 97.5% confidence interval between 0 and 0.99% (48).

For continuous and skewed variables, the Mann–Whitney *U* test was used to assess between-group differences and changes, and the Wilcoxon signed-rank test was used to assess within-group changes, as appropriate. Differences in independent categorical variables between two subgroups were analyzed using Fisher's exact test, and differences in related categorical variables within groups were assessed using the McNemar test. Relationships between variables of interest were assessed using Spearman and point-biserial correlation tests, as appropriate.

Multivariable logistic regression models, including variables with a p-value < 0.200 (49), with manual selection based on a probability of $F < 0.05$ were used to identify independent variables for predicting cured OSA using a parsimonious approach. The variance inflation factor (VIF) of each predictor was calculated to adjust for intervariable relationships within the model. The regression model was repeated after removing all variables with a VIF ≥ 5 to reduce multicollinearity (50).

To compare differences in the changes of outcome variables by post-intervention OSA status, generalized estimating equations with adjustments for pre-intervention age, sex, and obesity were used. Specifically, each subgroup variable was entered into separate generalized estimating equations that included the main effects of time (post-intervention vs. pre-intervention) and subgroup variable (e.g., boy vs. girl), a two-way interaction term of time × subgroup variable, and the main effects of baseline characteristics. A two-sided p-value of <0.05 was considered statistically significant.

3. Results

3.1. Groups of the study and between-group comparisons

Figure 1 demonstrates the flowchart of the present study. Fifty pediatric OSA patients (38 [76%] boys and 12 [24%] girls) with a median (IQR) age of 7.0 (5.8–10.0) years undergoing adenotonsillectomy with routine educational counseling (Group 1), 50 pediatric OSA patients (40 [80%] boys and 10 [20%] girls) with a median age of 7.4 (5.9–10.3) years undergoing adenotonsillectomy without formal educational counseling (Group 2), and 303 healthy children without obvious OSA symptoms (Control Group) were included for further analysis.

The Control Group in total had 303 healthy children (159 [52%] boys and 144 [48%] girls; median total OSA-18 score of 35 [28–43]), consisting of 45 (14.9%) 5-year-old, 44 (14.5%) 6-year-old, 39 (12.9%) 7-year-old, 43 (14.2%) 8-year-old, 38 (12.5%) 9-year-old, 45 (14.9%) 10-year-old, and 49 (16.2%) 11-year-old children. The median scores of sleep disturbance, physical suffering, emotional distress, daytime problems, and caregiver concerns of the OSA-18 questionnaire of the Control Group were 6 (5–8), 8 (5–11), 7 (4–9), 6 (4–9), and 7 (4–9), respectively. The difference in age between Group 1 and the Control Group was not significant ($p = 0.161$); however, the proportion of boys in Group 1 was significantly higher than that of the Control Group ($p = 0.002$). Because scores of the OSA-18 questionnaire and scales of the SFFQ questionnaire between boys and girls were comparable in Group 1 and Control Group, we did not perform further weighting procedures in the following statistical analyses.

Table 1 shows item/group-specific food frequencies in Group 1 (at baseline and post-adenotonsillectomy) and Control Group (at base line). In Group 1, the most consumed drinks in descending order of frequency were full-fat milk, orange juice and fruit drinks with sugar. The main consumed foods in descending order of frequency included vegetables, rice, fruit/berries, noodles, fish for dinner, and sweets. In the Control Group, all item/group-specific food frequencies between boys and girls were comparable. The most consumed drinks were full-fat milk, fruit drinks with sugar and soft drinks with sugar. The main items/groups of other foods included vegetables, rice, fruit/berries, fish for dinner, savory snacks, and noodles. In addition, Group 1 children ate fruit drinks with sugar, vegetables, sweets, chocolate, rice, and noodles more frequently than the Control Group children did. However, Group 1 children's daily consumption of vegetables and fruit/berries were significantly lower than those of Taiwanese children aged 7–12 years (vegetables: 1.8 times/day; fruits: 1.0 time/day) ($p = 0.013$ and < 0.001, respectively) (51).

Table 2 shows patient characteristics, scores of the OSA-18 questionnaire, and polysomnographic variables of Group 1 and Group 2 at baseline and post-adenotonsillectomy ≥6 months. At baseline, all variables were comparable between the two groups. The median scores of sleep disturbance, physical suffering, emotional distress, daytime problems, caregiver concerns, and total scores of the OSA-18 questionnaire of Group 1 and Group 2 (Table 2) were significantly higher than those of the Control Group.

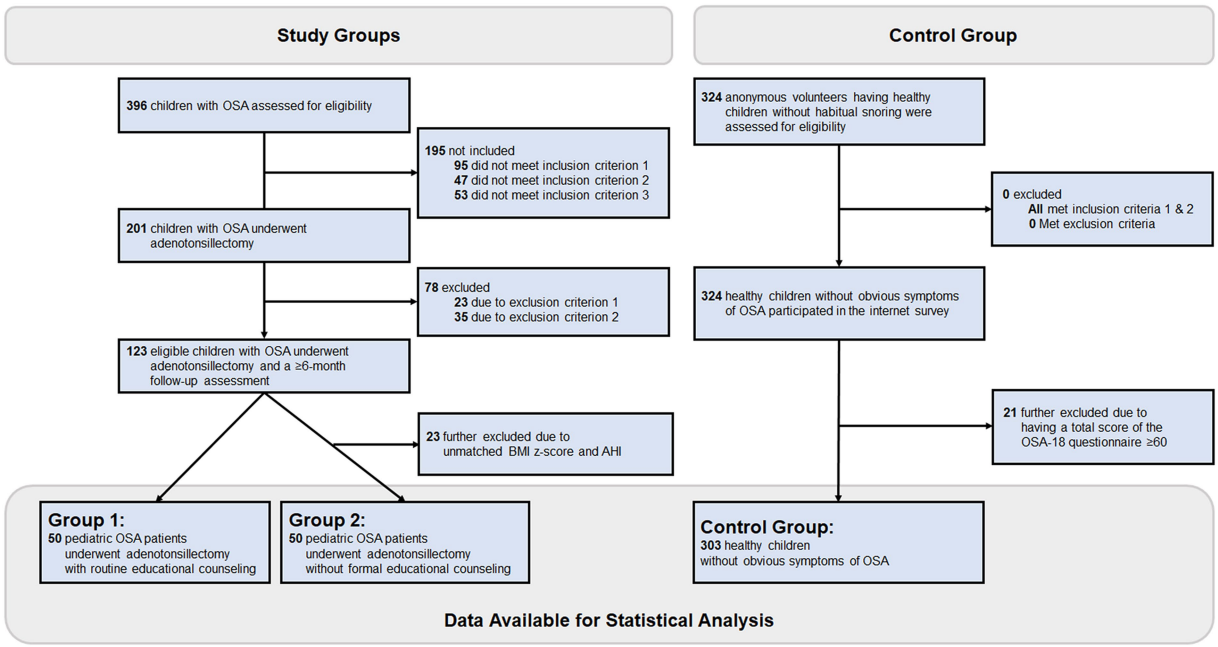

FIGURE 1
Flowchart of this observation study. Two-hundred one of 396 eligible children with OSA met the inclusion criteria of the study groups. Among them, 78 were excluded due to the exclusion criteria, and 23 were further excluded due to being unmatched by the AHI and BMI z-score between Group 1 (adenotonsillectomy with routine educational counseling) and Group 2 (adenotonsillectomy without formal educational counseling). Besides, 324 anonymous volunteers having healthy children without habitual snoring met the inclusion and exclusion criteria of the control group, and 21 were further excluded due to having a total score of the OSA-18 questionnaire ≥60. After that, the Control Group included 303 children without obvious OSA symptoms. AHI, apnea-hypopnea index; BMI, body mass index; OSA, obstructive sleep apnea.

The median follow-up time of Group 1 (12 [IQR, 12–15] months) and Group 2 (15 [IQR, 8–17] months) were comparable ($p = 0.950$).

After adenotonsillectomy, BMI z-scores of both Groups 1 and 2 significantly increased. The follow-up BMI z-score of Group 1 was significantly lower than that of Group 2. Both Group 1 and Group 2 had significantly reduced scores in five domains and total scores on the OSA-18 questionnaire (Table 2). The follow-up score of caregiver concerns of Group 1 was significantly lower than that of Group 2. Follow-up scores of physical suffering ($p = 0.057$), emotional distress ($p = 0.569$), and caregiver concerns ($p = 0.219$) of Group 1 were comparable to those of the Control Group; however, scores of sleep disturbance ($p < 0.001$) and daytime problems ($p = 0.007$), and total scores ($p < 0.001$) of Group 1 were still significantly higher than those of the Control Group. Follow-up scores of sleep disturbance ($p < 0.001$), physical suffering ($p = 0.001$), daytime problems ($p = 0.016$), and caregiver concerns ($p = 0.001$), and total scores ($p = 0.001$) were significantly higher in Group 2 than in the Control Group, while follow-up scores of emotional distress were comparable between Group 2 and Control Group ($p = 0.575$).

After adenotonsillectomy, Group 1 patients had significantly higher proportions of N2 sleep and rapid eye movement (REM) sleep, mean SpO_2 and minimal SpO_2, and significantly lower proportion of N3 sleep, AHI, apnea index, and arousal index. Group 2 had significantly higher mean SpO_2 and minimal SpO_2, and significantly lower proportion of N1 sleep, AHI, apnea index, and arousal index. Group 1 had a significantly lower follow-up proportion of N3 sleep and a higher mean SpO_2 than Group 2.

3.2. Within-group analysis and outcome prediction models in the Group 1

Figure 2 demonstrates several significant relationships between variables of interest in Group 1 at baseline. Notably, AHI was inversely related to chocolate, whereas the apnea index was inversely associated with noodles.

Although post-adenotonsillectomy changes in item/group-specific food frequencies were not significant in Group 1, excessive consumption of fruit drinks with sugar, chocolate, and noodles no longer persisted (Table 1). However, Group 1 children drank low-fat milk and still ate vegetables, sweets, and rice more frequently than the Control Group children.

Twenty-five (50%) children had cured OSA, and 25 (50%) had residual OSA. The baseline characteristics of the two outcome subgroups are shown in Table 3. Notably, those with cured OSA were significantly younger than those who had residual OSA. The ANR of those with cured OSA was significantly higher than those who had residual OSA. Furthermore, the proportions of REM stage sleep, mean SpO_2, and snoring index of those with cured OSA were significantly higher than those who had residual OSA. The rest of the variables of interest were comparable between the two outcome subgroups.

After adjustments for baseline age, sex, and obesity (Table 4), the change in fish for dinner for those with cured OSA was significantly higher than for those with residual OSA. In addition, changes in noodles and REM sleep for those with cured OSA were significantly lower than those with residual OSA. The changes in butter/margarine on bread and snoring index between the two subgroups were no

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TABLE 1 Item/group-specific food frequencies in Group 1 (at baseline and post-intervention) and Control Group (baseline).

	Group 1				Control Group		
	Before	After					
Items/Groups	$N = 50$	$N = 50$	Changes	p^a	$N = 303$	p^b	p^c
Full-fat milk (scale)	2 (1–3)	2 (2–3)	0 (0–1)	0.075	2 (1–3)	0.677	0.347
Low-fat milk (scale)	0 (0–0)	**0 (0–0)**	0 (0–0)	0.168	**0 (0–0)**	0.316	**0.009**
Semi-skimmed milk (scale)	0 (0–0)	0 (0–0)	0 (0–0)	0.317	0 (0–0)	0.995	0.316
Skimmed milk (scale)	0 (0–0)	0 (0–0)	0 (0–0)	0.414	0 (0–0)	0.548	0.889
Orange juice (scale)	1 (0–1)	0 (0–1)	0 (−1–0)	0.564	0 (0–1)	0.082	0.393
Fruit drink with sugar (scale)	**1 (1–2)**	1 (0–1)	0 (−1–0)	0.130	**1 (0–1)**	**0.020**	0.544
Fruit drink without sugar (scale)	0 (0–1)	0 (0–1)	0 (0–0)	0.833	0 (0–1)	0.860	0.640
Soft drinks with sugar (scale)	0 (0–1)	1 (0–2)	0 (0–1)	0.679	1 (0–1)	0.928	0.398
Soft drinks without sugar (scale)	0 (0–0)	0 (0–0)	0 (0–0)	0.257	0 (0–1)	0.193	0.979
Boiled potatoes (scale)	0 (0–0)	0 (0–1)	0 (0–0)	0.819	0 (0–1)	0.634	0.847
Potato chips (scale)	1 (0–1)	1 (1–1)	0 (0–0)	0.371	1 (0–1)	0.490	0.139
Vegetables (scale)	**5 (4–5)**	**5 (3–5)**	0 (−1–0)	0.276	**4 (3–5)**	**<0.001**	**0.009**
Fruit/berries (scale)	3 (2–4)	3 (2–4)	0 (−1–1)	0.951	3 (2–4)	0.692	0.761
Whole meal bread (scale)	1 (0–1)	1 (0–1)	0 (0–0)	0.701	0 (0–1)	0.368	0.446
Fish for dinner (scale)	2 (1–3)	2 (1–3)	0 (−1–1)	0.544	2 (1–3)	0.567	0.798
Pizza (scale)	0 (0–1)	0 (0–1)	0 (0–1)	0.072	1 (0–1)	0.170	0.572
Hamburgers/hot dogs/kebabs (scale)	1 (0–1)	1 (0–1)	0 (0–1)	0.285	1 (0–1)	0.633	0.105
Sweets (scale)	**2 (1–2)**	**1 (1–2)**	0 (−1–0)	0.592	**1 (1–2)**	**<0.001**	**0.009**
Chocolate (scale)	**1 (1–2)**	1 (0–2)	0 (−1–0)	0.333	**1 (0–1)**	**<0.001**	0.085
Savory snacks (scale)	1 (1–2)	1 (1–2)	0 (−1–1)	0.880	2 (1–2)	0.128	0.098
Peanuts (scale)	0 (0–1)	0 (0–1)	0 (0–0)	0.549	0 (0–1)	0.124	0.180
Cod liver oil/vitamin supplements (scale)	0 (0–1)	0 (0–1)	0 (0–0)	0.166	0 (0–2)	0.257	0.435
Butter/margarine on bread (yes)	21 (42)	23 (46)	0 (0–0)	0.815	124 (42)	>0.999	0.540
Rice (scale)	**5 (5–5)**	**5 (4–5)**	0 (−1–0)	0.371	**3 (3–5)**	**<0.001**	**<0.001**
Noodles (scale)	**3 (2–4)**	3 (2–3)	0 (−1–1)	0.554	**2 (2–3)**	**0.048**	0.136

Results are presented as median (interquartile range) for continuous variables and as absolute number (relative frequency) for categorical variables. Bold font indicates statistically significant differences ($p < 0.05$). [a] Within-group comparisons were performed using the related-samples Wilcoxon signed-rank test for continuous variables or related-samples McNemar test for categorical variables, as appropriate. [b] Data between values before the intervention and normal values were compared using the Mann–Whitney *U* test for continuous variables or Fisher's exact test for categorical variables, as appropriate. [c] Data between values after the intervention and normal values were compared using the Mann–Whitney *U* test for continuous variables or Fisher's exact test for categorical variables, as appropriate.

longer significant after adjustment. Furthermore, changes in other variables of interest were comparable between the two subgroups before and after adjustment.

Significant associations were found between changes in SFFQ item/group scores and changes in BMI z-score, OSA-18 domain scores, and changes in polysomnographic parameters (Figure 3). Notably, change in AHI was inversely related to change in cod liver oil/vitamin supplements. Change in apnea index was inversely correlated with changes in fish for dinner and cod liver oil/vitamin supplements.

To construct prediction models for cured OSA, we included baseline variables with a *p*-value <0.200 (Tables 3, 4; not including changes in polysomnographic parameters), including age, male sex, tonsil size, ANR, potato chips, fruit/berries, fish for dinner, noodles, REM sleep, arousal index, mean SpO_2, snoring index, change in skimmed milk, change in fish for dinner, change in butter/margarine

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TABLE 2 Demographic metrics and sleep variables of Group 1 and Group 2 at baseline and post-intervention ≥6months.

	Group 1	Group 2	
	Adenotonsillectomy with routine educational counseling	Adenotonsillectomy without formal educational counseling	
Variables	*N* =50	*N* =50	*p*[a]
Patients' characteristics			
Age (year)	7.0 (5.8–10.0)	7.40 (5.9–10.3)	0.493
Sex (girls/boys)	12/38	10/40	0.810
BMI z-score			
Baseline	**0.685 (−0.475–2.100)**	**1.370 (0.205–2.110)**	0.203
Post-AT	**1.305 (−0.218–2.173)**	**2.000 (1.260–2.289)**	**0.010**
Change	0.135 (−0.023–0.713)	0.190 (0.010–0.873)	0.503
p-value[b]	**0.002**	**0.001**	
Tonsil size (grade)	3 (3–4)	3 (3–4)	0.359
ANR	0.791 (0.665–0.869)	0.826 (0.760–0.850)	0.149
OSA-18 questionnaire			
Sleep disturbance (score)			
Baseline	**18 (15–22)**	**19 (17–23)**	0.391
Post-AT	**9 (8–11)**	**9 (7–11)**	0.639
Change	−10 (−13–−5)	−10 (−14–−7)	0.600
p-value[b]	**<0.001**	**<0.001**	
Physical symptoms (score)			
Baseline	**17 (15–19)**	**18 (15–21)**	0.699
Post-AT	**11 (8–13)**	**11 (9–16)**	0.092
Change	−7 (−11–−3)	−7 (−9–−2)	0.356
p-value[b]	**<0.001**	**0.001**	
Emotional distress (score)			
Baseline	**10 (7–13)**	**11 (8–12)**	0.918
Post-AT	**8 (5–10)**	**6 (5–8)**	0.434
Change	−3 (−5–−1)	−3 (−6–−2)	0.596
p-value[b]	**<0.001**	**0.001**	
Daytime problems (score)			
Baseline	**11 (9–14)**	**12 (10–13)**	0.974
Post-AT	**8 (6–10)**	**8 (6–10)**	0.891
Change	−3 (−6–0)	−4 (−6–−2)	0.575
p-value[b]	**<0.001**	**0.001**	
Caregiver concerns (score)			
Baseline	**18 (15–22)**	**18 (15–22)**	0.741
Post-AT	**8 (6–11)**	**9 (7–12)**	**0.036**
Change	−10 (−14–−6)	−8 (−11–−4)	0.137
p-value[b]	**<0.001**	**0.001**	
Total score			
Baseline	**77 (69–91)**	**77 (64–86)**	0.362
Post-AT	**53 (43–60)**	**44 (36–54)**	0.199
Change	−31 (−47–−19)	−33 (−41–−18)	0.986
p-value[b]	**<0.001**	**<0.001**	

(Continued)

TABLE 2 (Continued)

	Group 1	Group 2	
Polysomnography			
Total sleep time (minutes)			
Baseline	336 (304–351)	324 (296–350)	0.164
Post-AT	340 (320–351)	344 (322–349)	0.680
Change	2 (−17–36)	12 (−7–43)	0.311
p-value[b]	0.377	0.056	
N1 sleep (%)			
Baseline	10.3 (6.2–17.3)	**9.6 (7.4–14.7)**	0.986
Post-AT	9.7 (7.0–14.4)	**8.6 (4.6–12.0)**	0.061
Change	−0.1 (−6.4–6.2)	−2.5 (−8.8–2.3)	0.243
p-value[b]	0.383	**0.025**	
N2 sleep (%)			
Baseline	**40.2 (31.4–45.2)**	38.3 (32.6–42.9)	0.398
Post-AT	**43.0 (37.4–48.2)**	41.1 (36.3–47.2)	0.291
Change	2.6 (−1.6–8.6)	2.8 (−3.7–9.2)	0.850
p-value[b]	**0.017**	0.087	
N3 sleep (%)			
Baseline	**26.1 (22.5–32.2)**	30.3 (21.9–35.4)	0.276
Post-AT	**24.0 (20.1–27.8)**	**29.6 (23.3–35.2)**	**0.002**
Change	−1.9 (−8.9–1.4)	−1.3 (−10.5–10.3)	0.071
p-value[b]	**0.006**	0.577	
REM sleep (%)			
Baseline	**19.2 (13.3–22.7)**	20.2 (16.0–22.6)	0.243
Post-AT	**21.3 (17.4–25.3)**	19.7 (16.1–21.8)	0.163
Change	3.7 (−3.6–9.6)	2.1 (−3.7–5.0)	0.117
p-value[b]	**0.006**	0.497	
AHI (events/h)			
Baseline	**8.8 (4.1–23.3)**	**15.4 (7.5–29.7)**	0.128
Post-AT	**2.9 (1.9–5.5)**	**3.8 (1.7–9.0)**	0.351
Change	−6.1 (−15.5–−0.7)	−5.7 (−19.8–−0.8)	0.973
p-value[b]	**<0.001**	**<0.001**	
Apnea index (events/h)			
Baseline	**1.8 (1.0–4.4)**	**2.0 (0.6–7.1)**	0.764
Post-AT	**1.1 (0.2–1.6)**	**1.0 (0.4–2.3)**	0.423
Change	−0.7 (−3.4–0.0)	−0.8 (−2.9–0.5)	0.597
p-value[b]	**<0.001**	**0.007**	
Arousal index (events/h)			
Baseline	**10.9 (7.7–18.7)**	**12.9 (7.8–21.1)**	0.506
Post-AT	**7.9 (5.6–10.5)**	**7.6 (6.3–12.2)**	0.468
Change	−3.6 (−9.8–0.3)	−3.8 (−13.2–0.6)	0.901
p-value[b]	**<0.001**	**0.001**	
Mean SpO_2 (%)			
Baseline	**97 (97–98)**	97 (96–98)	0.070
Post-AT	**98 (97–98)**	**97 (97–98)**	**0.015**

(Continued)

TABLE 2 (Continued)

	Group 1	Group 2	
Change	0 (0–1)	0 (0–1)	0.807
p-value[b]	**0.009**	0.206	
Minimal SpO_2 (%)			
Baseline	**89 (84–92)**	**86 (82–90)**	0.084
Post-AT	**91 (89–94)**	**91 (86–92)**	0.059
Change	2 (0–7)	3 (−1–7)	0.645
p-value[b]	**<0.001**	**<0.001**	
Snoring index (events/h)			
Baseline	312.6 (103.0–469.9)	193.2 (97.7–392.2)	0.230
Post-AT	188.6 (68.4–362.1)	131.5 (1.9–307.6)	0.092
Change	−127.5 (−346.6–149.8)	−97.8 (−274.5–170.6)	0.415
p-value[b]	0.072	0.386	

Results are presented as median (interquartile range) for continuous variables and as absolute number for categorical variables. Bold font indicates statistically significant differences ($p < 0.05$).
[a] Data were compared using the independent-samples Mann–Whitney *U* test for continuous variables and Fisher's exact test for categorical variables. [b] Data were compared using the related-samples Wilcoxon signed-rank test for continuous variables. AHI, apnea-hypopnea index; ANR, adenoidal-nasopharyngeal ratio; AT, adenotonsillectomy; BMI, body mass index; OSA, obstructive sleep apnea; REM, rapid eye movement; SpO_2, peripheral oxygen saturation.

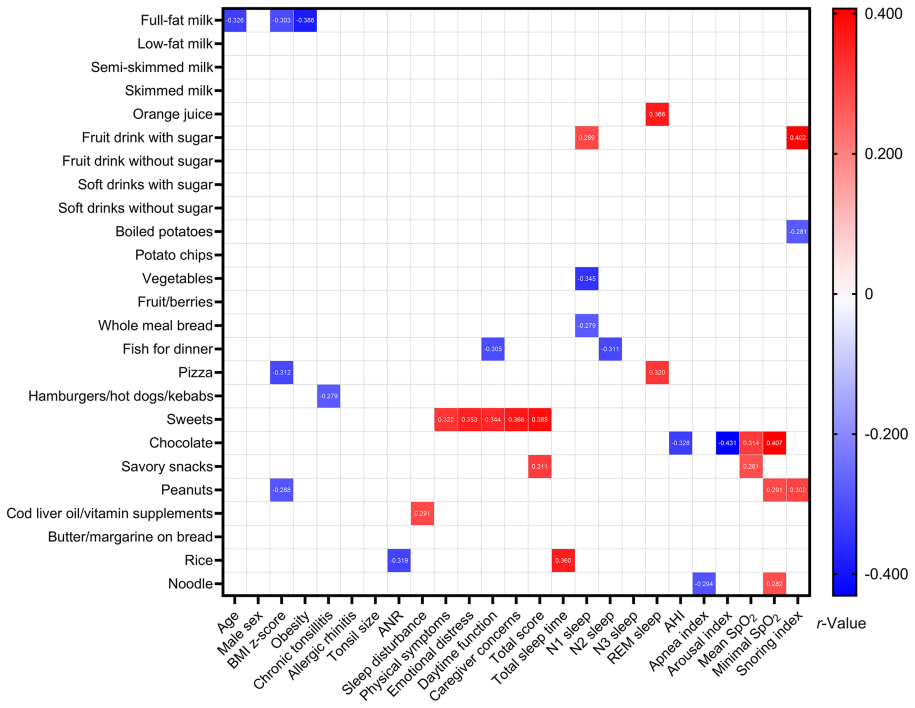

FIGURE 2
Associations between variables of interest among Group 1 at baseline. Data are summarized as Spearman's or point-biserial *rho*, as appropriate. Blank spaces mean two-sided *p*-values ≥0.05.

on bread, and change in noodles in multivariable logistic regression analyses.

Table 5 summarizes the full model and the final parsimonious model to predict cured OSA. After removing variables with a VIF ≥ 5 (ANR, arousal index, mean SpO_2), the full model identified age and change in butter/margarine on bread as independent predictors under the control of male sex, tonsil size, potato chips, fruit/berries, fish for dinner, noodles, REM sleep, snoring index, change in skimmed milk, change in fish for dinner, and change in noodles. The parsimonious model (including baseline clinical variables and changes in food items/groups) identified age, change in butter/margarine on bread, and change in noodles as the best predictors of cured OSA.

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TABLE 3 Baseline characteristics of the children with cured OSA and those had residual OSA after intervention in Group 1.

	Cured OSA	Residual OSA	
Characteristics	*N* =25	*N* =25	*p*[a]
Patient characteristics			
Age (years)	**6.0 (5.0–7.0)**	**9.0 (7.0–10.5)**	**0.001**
Male sex, *n* (%)	16 (64)	22 (88)	0.095
BMI (kg/m^2) z-score	0.380 (−0.610–1.945)	1.190 (−0.365–2.300)	0.443
Obesity, *n* (%)	11 (44)	13 (52)	0.778
Chronic tonsillitis, *n* (%)	5 (20)	5 (24)	>0.999
Allergic rhinitis, *n* (%)	19 (76)	18 (72)	>0.999
Tonsil size	3 (3–4)	3 (3–4)	0.164
ANR	**0.811 (0.736–0.882)**	**0.744 (0.634–0.844)**	**0.028**
Short food frequency questionnaire			
Full-fat milk (scale)	2 (2–3)	2 (1–3)	0.563
Low-fat milk (scale)	0 (0–0)	0 (0–0)	0.503
Semi-skimmed milk (scale)	0 (0–0)	0 (0–0)	0.317
Skimmed milk (scale)	0 (0–0)	0 (0–0)	0.317
Orange juice (scale)	1 (0–1)	1 (0–1)	>0.999
Fruit drink with sugar (scale)	1 (1–2)	1 (1–2)	0.806
Fruit drink without sugar (scale)	0 (0–1)	0 (0–1)	0.961
Soft drinks with sugar (scale)	0 (0–2)	0 (0–1)	0.501
Soft drinks without sugar (scale)	0 (0–0)	0 (0–0)	0.493
Boiled potatoes (scale)	0 (0–1)	0 (0–0)	0.472
Potato chips (scale)	1 (0–1)	1 (1–1)	0.115
Vegetables (scale)	5 (4–5)	5 (4–5)	0.251
Fruit/berries (scale)	4 (3–4)	3 (2–4)	0.165
Whole meal bread (scale)	1 (0–1)	0 (0–2)	0.859
Fish for dinner (scale)	2 (1–3)	2 (1–4)	0.108
Pizza (scale)	0 (0–1)	0 (0–1)	0.688
Hamburgers/hot dogs/kebabs (scale)	1 (0–1)	1 (0–1)	0.324
Sweets (scale)	2 (1–2)	2 (1–2)	0.875
Chocolate (scale)	1 (1–2)	1 (1–2)	0.992
Savory snacks (scale)	2 (1–2)	1 (1–3)	0.669
Peanuts (scale)	0 (0–1)	0 (0–1)	0.818
Cod liver oil/vitamin supplements (scale)	0 (0–1)	0 (0–1)	0.665
Butter/margarine on bread (yes)	0 (0–1)	0 (0–1)	0.903
Rice (scale)	5 (5–5)	5 (5–6)	0.215
Noodles (scale)	3 (2–4)	2 (2–3)	0.069
OSA–18 questionnaire			
Sleep disturbance (score)	19 (16–22)	17 (14–23)	0.366
Physical symptoms (score)	18 (15–19)	17 (13–20)	0.668
Emotional distress (score)	10 (7–12)	10 (7–16)	0.690
Daytime function (score)	11 (7–14)	12 (9–15)	0.242
Caregiver concerns (score)	19 (15–23)	17 (14–22)	0.472
Total score	86 (69–92)	76 (68–93)	0.992
Polysomnographic parameters			
Total sleep time (minutes)	337 (330–350)	333 (289–351)	0.277

(Continued)

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TABLE 3 (Continued)

	Cured OSA	Residual OSA	
N1 sleep (%)	9.4 (6.4–15.6)	10.4 (5.9–21.9)	0.607
N2 sleep (%)	40.5 (32.8–46.1)	40.1 (31.4–45.4)	0.938
N3 sleep (%)	27.5 (22.9–35.7)	26.0 (21.5–30.5)	0.720
REM sleep (%)	**20.7 (17.7–23.2)**	**16.3 (11.0–22.4)**	**0.029**
AHI (events/h)	6.1 (3.7–18.8)	14.8 (4.2–26.3)	0.308
Apnea index (events/h)	2.0 (1.3–4.5)	1.3 (0.6–4.1)	0.252
Arousal index (events/h)	9.1 (7.1–15.9)	13.9 (8.6–22.8)	0.095
Mean SpO_2 (%)	**98 (97–98)**	**97 (97–98)**	**0.049**
Minimal SpO_2 (%)	90 (84–92)	89 (84–92)	0.335
Snoring index (events/h)	**388.0 (175.2–485.5)**	**148.1 (25.4–430.4)**	**0.049**

Results are presented as median (interquartile range) for continuous variables and as absolute number (relative frequency) for categorical variables. Bold font indicates statistically significant differences ($p < 0.05$). [a] Data were compared using the Mann–Whitney *U* test for continuous variables or Fisher's exact test for categorical variables, as appropriate. AHI, apnea-hypopnea index; ANR, adenoidal-nasopharyngeal ratio; BMI, body mass index; OSA, obstructive sleep apnea; REM, rapid eye movement; SpO_2, peripheral oxygen saturation.

TABLE 4 Changes in the characteristics of the children with cured OSA and those had residual OSA after intervention in Group 1.

	Cured OSA	Residual OSA		
Changes in characteristics	*N* =25	*N* =25	p^a	p^b
Patient characteristic				
BMI (kg/m^2) z-score	0.120 (−0.070–0.820)	0.170 (−0.010–0.695)	0.930	0.524
Short form food frequency questionnaire				
Full-fat milk (scale)	0 (0–1)	0 (0–1)	0.214	0.406
Low-fat milk (scale)	0 (0–0)	0 (0–0)	0.693	0.601
Semi-skimmed milk (scale)	0 (0–0)	0 (0–0)	0.317	0.306
Skimmed milk (scale)	0 (0–0)	0 (0–0)	0.556	0.177
Orange juice (scale)	0 (−1–0)	0 (−1–0)	0.395	0.320
Fruit drink with sugar (scale)	0 (−1–0)	0 (−1–0)	0.559	0.692
Fruit drink without sugar (scale)	0 (−1–0)	0 (0–1)	0.296	0.691
Soft drinks with sugar (scale)	0 (−1–1)	0 (0–1)	0.539	0.623
Soft drinks without sugar (scale)	0 (0–0)	0 (0–1)	0.332	0.530
Boiled potatoes (scale)	0 (−1–0)	0 (0–0)	0.334	0.205
Potato chips (scale)	0 (0–1)	0 (−1–0)	0.076	0.210
Vegetables (scale)	0 (−1–0)	0 (−1–1)	0.801	0.756
Fruit/berries (scale)	0 (−2–1)	0 (−1–1)	0.369	0.249
Whole meal bread (scale)	0 (0–1)	0 (−1–0)	0.151	0.210
Fish for dinner (scale)	**1 (−1–2)**	**0 (−1–1)**	0.083	**0.024**
Pizza (scale)	0 (0–1)	0 (0–1)	0.618	0.945
Hamburgers/hot dogs/kebabs (scale)	0 (0–1)	0 (−1–1)	0.188	0.865
Sweets (scale)	0 (−1–0)	0 (−1–1)	0.918	0.821
Chocolate (scale)	0 (−1–0)	0 (−1–1)	0.748	0.866
Savory snacks (scale)	0 (−1–0)	0 (−1–1)	0.237	0.184
Peanuts (scale)	0 (0–0)	0 (−1–1)	0.957	0.936
Cod liver oil/vitamin supplements (scale)	0 (0–0)	0 (0–0)	0.918	0.457
Butter/margarine on bread (yes)	**0 (−1–0)**	**0 (0–1)**	**0.046**	0.146
Rice (scale)	0 (−1–0)	0 (−1–0)	0.991	0.929

(Continued)

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TABLE 4 (Continued)

	Cured OSA	Residual OSA		
Noodles (scale)	**-1 (−2–0)**	**0 (0–1)**	**0.041**	**0.033**
OSA-18 questionnaire				
Sleep disturbance (score)	−11 (−13–−7)	−9 (−12–−3)	0.173	0.294
Physical symptoms (score)	−8 (−12–−4)	−6 (−10–−2)	0.240	0.789
Emotional distress (score)	−3 (−5–−2)	-2 (−8–1)	0.977	0.409
Daytime function (score)	−3 (−6–−5)	−3 (−6–0)	0.946	0.231
Caregiver concerns (score)	−11 (−15–−6)	−9 (−15–−5)	0.203	0.326
Total score	−33 (−47–−21)	−29 (−49–−8)	0.382	0.870
Polysomnographic parameters				
Total sleep time (minutes)	1 (−29–17)	11 (−16–58)	0.112	0.165
N1 sleep (%)	0.4 (−4.9–5.5)	−2.2 (−7.0–6.3)	0.547	0.432
N2 sleep (%)	1.5 (−5.2–7.8)	2.7 (−0.5–10.3)	0.362	0.372
N3 sleep (%)	−0.4 (−9.1–1.9)	−3.5 (−8.2–0.1)	0.229	0.362
REM sleep (%)	**2.0 (−4.2–7.1)**	**7.0 (−2.4–11.3)**	0.073	**0.022**
AHI (events/h)	−5.1 (−16.7–−1.1)	−9.9 (−16.0–0.3)	0.662	0.099
Apnea index (events/h)	−0.9 (−3.4–−0.3)	-0.3 (−3.1–0.2)	0.229	0.247
Arousal index (events/h)	−3.2 (−9.4–−1.5)	−4.3 (−10.8–0.3)	0.936	0.099
Mean SpO_2 (%)	0 (0–1)	0 (0–1)	0.773	0.091
Minimal SpO_2 (%)	3 (1–8)	2 (−1–5)	0.199	0.588
Snoring index (events/h)	**−187.0 (−440.0–−30.0)**	**30.4 (−227.7–294.8)**	**0.031**	0.163

Results are presented as median (interquartile range) for continuous variables and as absolute number (relative frequency) for categorical variables. Bold font indicates statistically significant differences ($p < 0.05$). [a] Between-group changes were compared using the Mann–Whitney *U* test for continuous variables. [b] Data were further compared using generalized estimating equation analyses adjusted for baseline age, sex, and/or obesity status. AHI, apnea-hypopnea index; ANR, adenoidal-nasopharyngeal ratio; BMI, body mass index; OSA, obstructive sleep apnea; REM, rapid eye movement; SpO_2, peripheral oxygen saturation.

4. Discussion

The current study demonstrated several novel and interesting findings on the dietary profiles of pediatric OSA patients, their differences compared to healthy children without OSA, the effectiveness of routine educational counseling, and predictors for cured OSA among patients receiving combined treatment.

The most commonly consumed food items/groups among pediatric OSA patients were full-fat milk, vegetables, rice, fruit/berries, noodles, fish for dinner, and sweets, and they had fruit drinks with sugar, vegetables, sweets, chocolate, rice, and noodles more frequently than the healthy control did. Daily fruit/berry consumptions in Group 1 and the Control Group were lower than the Taiwanese recommendation (3.5 servings per day) (37, 45). This is not uncommon in Taiwan; although healthy Taiwanese children have a higher median daily vegetable consumption than that of normal Norwegian children (37), the value is still lower than the recommendation (4–5 servings per day) from the Daily Dietary Guidelines of Taiwan for children aged 7–12 years (45). Likewise, Taiwanese children in general drink less full-fat milk than the recommended (1.5 glasses of milk/day) (45). Some child caregivers of our subjects reported that they reduced full-fat milk consumption and replaced it with low-fat milk to lower the risk of childhood obesity. The impacts of dairy foods and their low-fat products on cardio-metabolic health are still controversial, called the "dairy fat paradox" (52). Vanderhout et al. demonstrated that higher cow milk fat intake was related to lower childhood adiposity in a meta-analysis (53). However, most previous research focused on cardiovascular diseases, metabolic syndrome, or weight status as study outcomes; the role of full-fat milk consumption in pediatric OSA is still unclear and needs further investigation.

Consistent with Spruyt's study (47), the pediatric OSA patients with obesity in the present study ate more fast food and less healthy food, such as vegetables and fruits, than the children without OSA. Elevated ghrelin levels are positively associated with OSA, increased appetite and caloric intake in children with obesity (47). On the contrary, more frequent fruit consumption has been correlated with healthy sleep, including shorter nap duration (54) and long sleep duration in children (55). Our data combined with the literature indicated that education on healthy eating, such as more vegetable/fruit intake and less fast food, needs to be addressed more intensively among children in Taiwan, especially for pediatric OSA patients. The literature indicates that longer, better, and more regular sleep links to lower adiposity and better metabolic health (16). The educational counseling delivered in this study focused firstly on sleep hygiene, which was not only meant to directly improve the sleep and circadian rhythm of participants, but also the efforts in theory would have positive impacts on weight status and body composition. Moreover, the counseling promoted healthy eating and regular exercise, which were both well-documented effective methods to weight management (56).

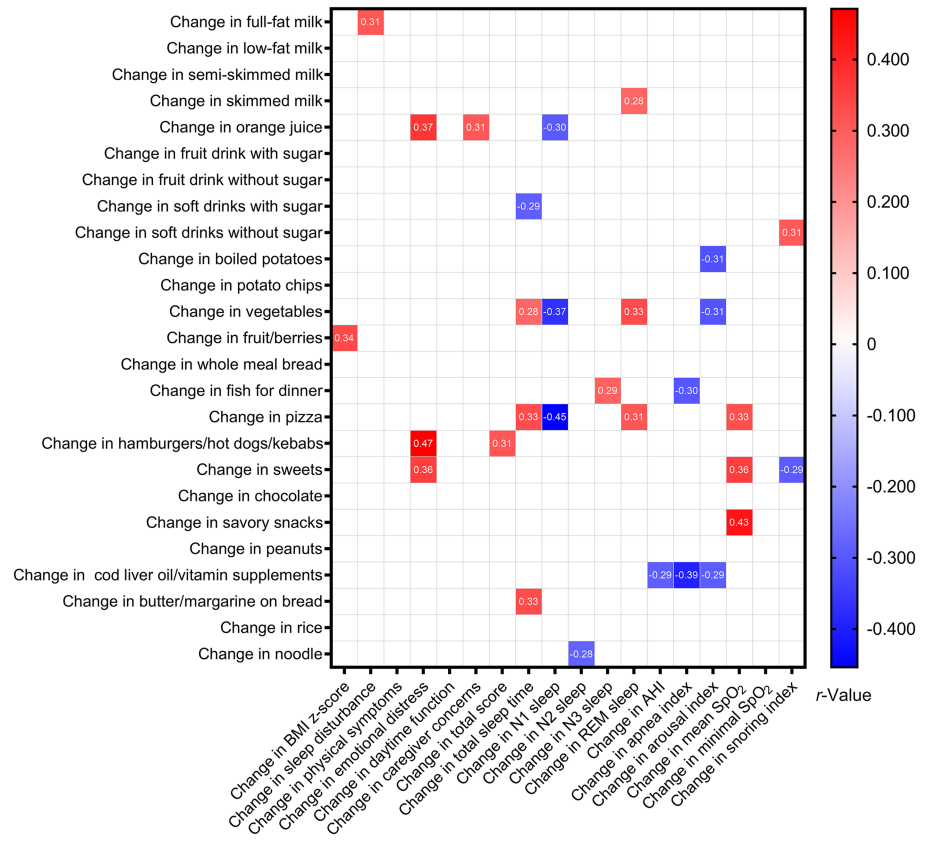

FIGURE 3
Associations between changes in variables of interest among Group 1 after intervention. Data are summarized as Spearman's or point-biserial *rho*, as appropriate. Blank spaces mean two-sided *p*-values ≥0.05.

Our data suggested that pediatric OSA patients receiving combined intervention might have additional treatment benefits other than solitary adenotonsillectomy. First, they had significantly increased N2 and REM sleep proportions and reduced N3 sleep proportion, which suggested a restoration of sleep architecture from disruption toward normal (57). Second, they had a significantly higher mean SpO_2 meant, which suggested that the sleep hypoxemia status could be improved by not only surgical treatment but also approaches to lifestyle modification such as sleep hygiene, healthy eating, and regular exercise. However, as current evidence supports that weight reduction through lifestyle and dietary interventions can improve OSA severity in adults, our routine educational counseling did not show effectiveness on significant changes in dietary behavior, weight status, or OSA severity, indicating that more intensive lifestyle interventions are needed to yield more substantial clinical outcomes.

The full multivariable logistic regression model showed that younger age and decreased use of butter/margarine on bread were significant predictors of cured OSA under the control of possible confounding factors in the full model. Older age is a well-recognized risk factor for residual OSA after adenotonsillectomy in children, together with obesity and neurological/developmental/craniofacial comorbidities (8, 11, 12). Butter and margarine are used as spreads on bread and for cooking and baking. Butter is a dairy product generated from milk, containing approximately 80% milk fat and 16% water, and is rich in saturated fats, proteins, calcium, phosphorus, and some essential fat-soluble vitamins (A, D, E) (58). Among children and adolescents, butter/margarine spread is significantly related to excessive weight gain (22). Similar to patients with adulthood OSA, improper dietary habits (such as the frequent use of butter/margarine spread or as a source of fat for cooking) has been associated with body weight gain and OSA (59). Consistent with the literature, our results suggest that a reduction in butter/margarine on bread may help weight control and decrease the severity of childhood OSA.

Interestingly, the parsimonious model further included reduced noodle consumption in addition to younger age and reduced butter/margarine on bread for predicting cured OSA. Noodles are a staple food in Asian countries, and they are made from wheat flour, water, starch, and salt. One hundred grams of noodles have approximately 138 kcal, 2.07 g fat, 25.2 g carbohydrate, 4.54 g protein, 1.2 g fiber, 67.7 g water, and 5 mg sodium (60). Excessive consumption of noodles has been linked to overweight and obesity among school-aged children and adolescents (61), and a higher intake of instant noodles may increase the risk of short sleep duration and poor sleep quality in adolescents (62). To our best knowledge, this study was the first to reveal a significant association between the consumption of noodles and OSA in children. However, since the change in noodle consumption was not related to the change in AHI, we postulated that a reduction in noodle consumption might connect to cured OSA via indirect pathways such as weight reduction.

Somatic growth and weight gain are frequently observed after adenotonsillectomy in children with or without OSA (36, 63, 64). These observations may be explained by the improved retro-nasal

TABLE 5 Prediction models for cured OSA after intervention in Group 1.

Predictors	Exp(β) (95% CI)	p	VIF	*Adjusted* R^2
Full model				
Age (years)	**0.368 (0.146–0.928)**	**0.034**	1.347	0.766
Male sex	0.079 (0.003–2.182)	0.134	1.427	
Tonsil size	7.739 (0.666–89.998)	0.102	1.370	
Potato chips (scale)	0.351 (0.025–4.997)	0.440	1.384	
Fruit/berries (scale)	1.904 (0.520–6.974)	0.331	1.424	
Fish for dinner (scale)	0.337 (0.081–1.407)	0.136	1.583	
Noodles (scale)	3.733 (0.770–18.108)	0.102	2.009	
REM sleep (%)	1.093 (0.883–1.352)	0.414	1.262	
Snoring index (events/h)	1.003 (0.997–1.009)	0.332	1.493	
Change in skimmed milk (scale)	0.880 (0.115–6.750)	0.902	1.463	
Change in fish for dinner (scale)	1.135 (0.346–3.729)	0.835	1.656	
Change in butter/margarine on bread (scale)	**0.030 (0.001–0.652)**	**0.026**	1.198	
Change in noodles (scale)	0.379 (0.117–1.228)	0.106	1.845	
Parsimonious model				
Age (years)	**0.578 (0.399–0.837)**	**0.004**	1.015	0.521
Change in butter/margarine on bread (scale)	**0.097 (0.019–0.512)**	**0.006**	1.022	
Change in noodles (scale)	**0.573 (0.329–0.999)**	**0.049**	1.021	

ANR, adenoidal-nasopharyngeal ratio; CI, confidence interval; OSA, obstructive sleep apnea; REM, rapid eye movement; SpO_2, peripheral oxygen saturation; VIF, variance inflation factor. Bold font indicates statistically significant differences ($p < 0.05$).

olfactory function and consequently increased appetite after tonsil and adenoid removal (65). We conducted routine educational counseling for pediatric OSA patients in Group 1 to promote a healthy lifestyle. Some positive impacts were observed on sleep architecture, oxygenation, and undesirable eating habits. However, item/group-specific food frequencies did not change significantly after a 12-month follow-up, suggesting more intensive educational counseling was needed to yield profound change in food literacy. A multidisciplinary team, including family physicians, nurses, clinical dietitians, social workers, and administrative employees from schools, with a longer interventional duration, may be more effective (66). Besides, like multidisciplinary weight loss interventions in youth (10–19 years old) with obesity, educational counseling with more sessions (10–20 times) for a more extended period (4–12 months) may be more likely to result in improvement of clinical outcomes such as weight status and disease severity.

The greatest strength of this investigation was the inclusion of both a sample of representative and well-characterized pediatric OSA patients and a large sample of healthy children as the control. Furthermore, a long-term follow-up after adenotonsillectomy was completed for pediatric OSA patients. This design allowed a detailed description of diet behaviors across several factors, which we co-adjusted to identify independent associations with cured OSA. Nevertheless, these results need to be interpreted in consideration of some limitations. First, the completeness rate of Group 1 was lower than anticipated (76%), which might be attributed to the outbreak of COVID-19 in Taiwan during the study period. Second, a high degree of heterogeneity in the study groups might lead to increased type II errors due to a lack of statistical power (range: 36–99%), especially in comparing the intervention success group and the residual disorder group in Group 1. Third, the number of routine educational sessions conducted in our study was limited. As previously acknowledged, a larger number of sessions with an extended duration may be more effective in inducing substantial dietary modifications. Forth, although the SFFQ has been reported comparable to the four-day recoded food diary (regarding consumption frequencies and mean intake of food) and the 24-h dietary recall (regarding nutrients intake) (67), this western-country developed questionnaire may not be able to fully reflect the food literacy of Asian children. The lack of change in food frequencies could be a result of the ineffectiveness of the educational counseling, but it could also be due to methodological limitations. Furthermore, tastes/interests in young children vary frequently; other food frequency questionnaires with shorter intervals may reflect more recent diet habits without recall bias. Lastly, the role of sleep hygiene in food preferences, weight status, and OSA severity are not well-established and needs to be further delineated. Nevertheless, our preliminary findings warrant future investigations; a more intricate case–controlled study or a randomized controlled trial with a larger sample will be of interest.

In conclusion, the present study preliminarily characterized a relatively unhealthy dietary profile in pediatric OSA patients compared with the healthy control or the domestic daily dietary recommendations. The results showed that educational counseling in routine workups led to subjective and objective improvements in sleep outcomes after adenotonsillectomy; however, food consumption frequency was not changed substantially. Consumption frequently of certain food items/groups, including butter/margarine on bread and noodles, may be involved in the resolution of OSA after intervention.

Given the potential beneficial effects of nutritional interventions on weight control and OSA amelioration, approaches including these item/group-specific foods could be a strategy for the comprehensive management of childhood OSA.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The study involving human participants was reviewed and approved by the Institutional Review Board of the Chang Gung Medical Foundation, Taoyuan, Taiwan (202000873B0 and 202201649B0). Written informed consent from the patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

H-HC, R-HL, J-FH, and L-AL conceived and planned the study. H-HC, J-FH, L-PC, H-YL, Y-SH, and L-AL enrolled the patients. H-HC, R-HL, J-FH, Y-SH, AY, G-SL, TK, CY, and L-AL designed the study, analyzed the data, made the statistics, and interpreted the results. H-HC, R-HL, J-FH, L-PC, and L-AL participated in manuscript drafting. H-YL, T-JF, AY, G-SL, TK, and CY supervised the study. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The prevalence and predictors of feeding difficulties in children at self-feeding transition stage

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Aim: To understand the prevalence of feeding difficulties (FD) in young children at self-feeding transition stage (6–24 months age), and the protective and risk predictors associated with FD are to be determined through this study.
Methods: A cross-sectional study was conducted within 5 representative Women's and Children's hospitals in Chengdu, Southwest China. Children age 6–24 months who underwent routine child health care examination at outpatient and their parents were enrolled, while the Montreal Children's Hospital Feeding Scale which is validated was used to determine whether these children have FD.
Results: A total of 1,211 subjects were enrolled in this survey, where 380 children were reported as FD with an prevalence of 31.4%. Adjusted binary logistic regression in the multivariate analysis showed 10 independent predictors of FD. Specifically there were 6 risk predictors: (1) frequent constipation (*OR* = 1.603, *CI* = 1.006–2.555) in CHILD sub-theme; (2) anxiety (*OR* = 4.322, *CI* = 3.074–6.079) and (3) indulgent parenting style (*OR* = 2.108, *CI* = 1.306–3.405) in PARENT sub-theme; (4) luring to eat (*OR* = 2.806, *CI* = 2.000–3.937), (5) forcing to eat (*OR* = 2.040, *CI* = 1.407–2.958), and (6) allowing playing during mealtime (*OR* = 2.023, *CI* = 1.435–2.853) in FEEDING PRACTICE sub-theme. The remaining 4 factors were protective predictors including (1) food preparing (*OR* = 0.586, *CI* = 0.385–0.891) in FOOD sub-theme; (2) observing hunger and satiety signals (*OR* = 0.667, *CI* = 0.457–0.974), (3) interacting with child during mealtime (*OR* = 0.505, *CI* = 0.308–0.828), as well as (4) providing exclusive tableware (*OR* = 0.370, *CI* = 0.191–0.719) in FEEDING PRACTICE sub-theme.
Conclusions: There appeared to be an increasing trend of FD prevalence. Child health care clinicians and pediatricians are expected to attach more importance to FD in their daily work, and are obliged to provide parents with practical and effective preventive strategies highlighted in this study.

KEYWORDS

feeding difficulties, prevalence, predictor, children, feeding practice

Introduction

A suitable and balanced nutritional intake has been proved essential for both physical growth and neuropsychological development of young children. Aware that feeding is an integrated process involving complex parent-child interaction (1), parents tend to experience stress trying to keep an appropriate diet for young children. In recent

Abbreviations:
FD, feeding difficulties; FDIEC, disorder in infancy and early childhood; ARFID, avoidant restrictive food intake disorder; PFD, pediatric feeding disorder; DSM-IV, the diagnostic and statistical manual of mental disorders.

decades, due to improved educational level of the populations, people have been paying more emphasis on child-raising, and more attention has been drawn to young children's feeding problems. Relevant literature has reported that up to 50% of parents claimed that their young children had various feeding problems, whose typical manifestations include poor appetite, food selectivity, sluggish eating, food refusal, prolonged dependence on liquid/soft food, poor chewing ability, temper tantrum, destructive behavior during mealtime, etc. These feeding problems are suggested to increase the risk of malnutrition and growth retardation, cause certain adverse impacts on children's growth and development (2, 3), or even threaten a far-reaching impact on their adulthood eating habits. Therefore, Feeding Difficulties (FD) is becoming a common and prominent issue to be tackled in the work of child health care and pediatric clinic.

In a broad sense, FD is an umbrella term which encompasses all spectrum of feeding problems, namely all that affect the process of supplying food for the child (4). But in practice, definitions of FD and its diagnostic criteria vary among different associations or experts based on their own perspectives and application convenience. In 1994, the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) proposed the concept of Feeding Disorder in Infancy and Early Childhood (FDIEC). While in 2013, DSM-V altered FDIEC to Avoidant Restrictive Food Intake Disorder (ARFID), defined as an eating or feeding disturbance in which children cannot maintain normal nutrition and exhibit food selectivity, poor appetite, or fear/anxiety about eating that is not related to cultural feeding practices. ARFID can be diagnosed when children fulfil at least one of the following four criteria: weight loss or poor growth, nutrient deficiency, dependence on oral or enteral supplements, and significant psychosocial dysfunction (5). More recently, a multi-disciplinary expert consensus in 2019 has put forward a unified diagnostic term for Feeding Difficulties—Pediatric Feeding Disorder (PFD). PFD is distinguished as a common clinical diagnosis which points out an inability to orally consume an age-appropriate diet, and should be diagnosed in the presence of dysfunction in at least one of four functional domains (medical, nutritional, skill and psychosocial) which persists for 3 months and beyond (6). Although both AFRID and PFD provide specific and detailed diagnostic criteria about FD, they are proved too strict and theoretical to be implemented in the clinic. Considering the utilizing convenience to identify and address FD, Kerzner has presented a functional and stepwise approach for clinicians to adopt when faced with children and parents undergoing FD (7). In Kerzner's studies (7–9), three principal categories of FD were defined as limited appetite, selective intake, and fear of feeding. 25%–50% of young children included in the studies were reported to have FD, but only 5%–10% needed intervention. Notably, certain red flags (i.e., warning signals) and practical feeding guidelines were strongly suggested by Kerzner in his proposal, which inspired us to carry out our research. Although not involved in Kerzner's studies, prevention of FD is believed by us to be of great significance for child health care clinicians and pediatricians, which involves understanding potential predictors of FD, and forming targeted preventive measures.

Self-feeding transition stage refers to a special period during which children transfer from being fed with liquid food to eating solid food on their own. According to the World Health Organization's recommendation that "from the age of 6 months, children should begin eating safe and adequate complementary foods while continuing to breastfeed for up to 2 years and beyond", the age between 6 and 24 months is often considered as the self-feeding transition stage (10). At this stage, young children need to go through the conversion from being fed human milk to other types of milk, experience foods with different textures and multiple flavors, and learn dining rules as well as to use their own tableware. In this dynamic process of conversion, any problem linked with "child, food, parent, feeding practice" may lead to a high risk of developing FD for young children (11). In addition, previous studies have proved that food preferences and eating disorders in adulthood are significantly correlated to eating behavior problems in the first 2 years of life (12, 13). However, numerous current studies related to FD are mainly focused on preschool and school-age children (3–12 years of age), whereas only few studies have been aimed to understand the prevalence and predictors of FD in young children 6–24 months of age. Thus, we conducted this multi-center cross-sectional survey to understand the prevalence of FD in young children at the self-feeding transition stage, and independent predictors including both risk and protective factors are screened through our study. Ultimately, we hope the results and conclusions we represent here will be able to offer meaningful insights and guidance to child health care clinicians and pediatricians, so as to provide aids for young children and their parents faced with FD.

Methods

Study design

This is a multi-center cross-sectional study conducted in Chengdu—the regional development center of Sichuan province in southwestern China. Five research centers were recruited in this study, of which three representative university-affiliated maternal and child health hospitals were selected by convenience, and two district maternal and child health hospitals were selected randomly (selected by the random number generator from SPSS 22.0 statistical software) out of eleven districts of Chengdu.

- West China Women's and Children's Hospital: West China Second University Hospital, Sichuan University
- Sichuan Province Maternity and Child Health Care Hospital
- Chengdu Women's and Children's Central Hospital
- Qingbaijiang District of Chengdu Maternity and Child Health Care Hospital
- Longquan District of Chengdu Maternity and Child Health Care Hospital

Samples and participants

We used PASS 15.0 software (NCSS, LLC, Kaysville, Utah, USA, ncss.com/software/pass.) to calculate our questionnaire sample size. The calculating model of confidence intervals for one proportion was run where confidence level $(1-\alpha) = 0.95$, confidence interval width = 0.04, and the proportion was set as 0.214 according to a previous prevalence study in China (14). As a result, the sample size desired in this study was 1,664 questionnaires. Considering varied daily outpatient visits of each research center, we allocated 400 questionnaires to each of the three university-affiliated hospitals and 232 questionnaires each to two district hospitals. This multi-center cross-sectional study conducted a consecutive recruitment from August 2021 to May 2022. Two research nurses were employed to distribute questionnaires to parents who happened to be at the outpatient clinics of child health care in each research center, and results were collected on the spot once the questionnaires were filled in. Meanwhile, to ensure the quality of the study, well-trained research nurses were available to provide consultation and help when parents encountered any difficulty and confusion during the surveys. Children and their parents who underwent routine child health care examination at these five hospitals were enrolled in the study. The inclusion criteria requested that the parents were supposed to show a normal level of cognition and communication skills, capable of completing the questionnaire, and that their children were of 6–24 months of age (corrected gestational age should be adopted in the case of preterm children) who have been supplied with complementary food for at least 2 weeks. Parents who refused to participate in this study were excluded. All the participants signed an informed consent before filling their questionnaires, and ethical approval was obtained for our study from the Ethics Committee of Western China Women's and Children's Hospital of Sichuan University (West China Second University Hospital, Sichuan University).

Measurements

The structured parent self-reported questionnaires involved in this study consisted of three parts. Firstly, there were demographic characteristics questionnaire including child age, caregiver, education of caregiver, parity, fetus number, maternal age, delivery, complication during pregnancy and household monthly income per capita. The remaining two parts included:

- Potential Predictors of FD Questionnaire: According to a Chinese expert Zhao's review of FD in infant, it is believed that the associated factors of FD during self-feeding transition stage mainly include children, food, parents and feeding practices (11). Therefore, this study designed a questionnaire to evaluate the potential associated factors of FD in children aged 6–24 months based on this viewpoint, and divided it into four sub themes as CHILD, FOOD, PARENT, and FEEDING PRACTICE. In addition, some of the items were designed based on the warning signs and specific practical methods mentioned by Dr. Kerzner's in his study on feeding difficulties (7–9). 8 factors were included in the CHILD sub-theme: gestational age, weight at birth, disease at birth, frequent constipation, frequent vomiting, frequent diarrhea, frequent food allergy and cow's milk protein allergy; 3 in FOOD: exclusive breastfeeding, time of introducing complementary food and food preparing; 4 in PARENT: anxiety, quarrels, parenting style [typically, parents choose a particular one out of four general parental feeding styles, which are responsive-responding to child's cues, controlling-overriding child's cues, indulgent-catering to child's desires, or neglectful-unaware of child's cues (9)] and time for parenting company; and 12 in FEEDING PRACTICE: observing hunger and satiety signals, training of self-feeding, luring to eat, forcing to eat, allowing playing during mealtime, interacting with child during mealtime, between-meal nibbles, meal time limit, providing exclusive tableware, providing fixed table and chair, quiet environment, and eating with parents. As can be seen, a total of 27 potential predictors were enrolled in this part of questionnaire.
- The Montreal Children's Hospital Feeding Scale: this scale with good reliability and validity was established by doctor M Ramsay to allow pediatricians and other health care professionals for a quick identification of FD in children from 6 months to 6 years of age (15). 14 parent-report items are graded based on a seven-point Likert scale. The total raw score is obtained by adding the scores for each item after reversing the scores of the 7 items graded from negative to positive. And the scoring sheet allows a quick conversion of raw scores into T-scores, which can then be classified as non-FD (below 61), mild (61–65), moderate (66–70) or severe (above 70). This scale was used in our study as a measurement of outcome indicators.

The questionnaire and scale used in this study has been translated into English and attached at the end of the manuscript, attached as **Supplementary Appendix S1**.

Data analysis

We used SPSS 22.0 statistical software (IBM Corp, Chicago, IL, USA, www.ibm.com/legal/copytrade.shtml) to analyze the statistical data. First, descriptive statistics is used to analyze demographic data and FD prevalence which were described as "mean score ± standard deviation" or "number (percentage)". Next, covariates were determined by *t*-test for continuous variables and chi-square test for categorical variables, to detect statistically significant differences of demographic baseline data between FD and Non-FD groups. Then, chi-square test was employed to select factors significantly associated with FD among 27 possible predictors under four sub-themes (the Fisher's Exact Test is required if the sample size is less than 5). Variables selected from univariate analysis were subsequently entered in a binary logistic regression model, where covariates were put in to adjust the model and categorical variables were processed as dummy variables. A *p*-value less than or equal to 0.05 was considered statistically significant.

Results

Demographic characteristics

A total of 1,211 valid questionnaires were returned with an effective rate of 72.78% (The effective rate of the five research centers are similar, with no significant difference between sites). Demographic characteristics are presented in Table 1. In comparing the baseline data between FD and non-FD groups, significant differences were detected in maternal age, complication during pregnancy and household monthly income per capita. Therefore, these were determined covariates that were later to be put in the logistic regression to adjust the model.

Prevalence of FD

Among 1,211 valid questionnaires, 380 children were reported as FD with an prevalence of 31.4%, including 167 cases of mild FD (13.8%), 117 moderate (9.7%), and 96 severe (7.9%). Details are illustrated in Figure 1.

TABLE 1 Difference of demographic characteristics between FD and non-FD groups.

Variables	FD ($n = 380$)	Non-FD ($n = 831$)	t/χ^2	p
Child age (month, mean ± std)	14.02 ± 5.45	13.68 ± 5.35	−1.011[a]	0.312
Child age (n, %)				
6–12 months	180 (47.4)	422 (50.8)		
13–18 months	126 (33.2)	258 (31.0)		
19–24 months	74 (19.4)	151 (18.2)	1.216[b]	0.544
Caregivers (n, %)				
Parents	241 (63.4)	569 (68.5)		
Grandparents	125 (32.9)	228 (27.4)		
Babysitters	14 (3.7)	34 (4.1)	3.768[b]	0.152
Education of caregivers (n, %)				
High school	142 (37.4)	268 (32.3)		
College or bachelor	218 (57.4)	507 (61.0)		
Master or PHD	20 (5.2)	56 (6.7)	3.500[b]	0.174
Parity (n, %)				
1	307 (80.8)	636 (76.5)		
≥2	73 (19.2)	195 (23.5)	2.740[b]	0.101
Fetus number (n, %)				
1	350 (92.1)	749 (90.1)		
≥2	30 (7.9)	82 (9.9)	1.209[b]	0.271
Maternal age (years, mean ± std)	30.20 ± 4.77	30.88 ± 4.34	2.447[a]	0.015*
Delivery (n, %)				
Natural labor	185 (48.7)	366 (44.0)		
Cesarean section	195 (51.3)	465 (56.0)	2.265[b]	0.132
Complication of pregnancy (n, %)				
No	263 (69.2)	628 (75.6)		
Yes	117 (30.8)	203 (24.4)	5.427[b]	0.020*
Household monthly income per capita (n, %)				
≤5,000 RMB	34 (8.9)	66 (7.9)		
5,000–10,000 RMB	195 (51.3)	368 (44.3)		
>10,000 RMB	151 (39.7)	397 (47.8)	6.814[b]	0.033*

FD, feeding difficulty; PHD, doctor of philosophy; std, standard deviation; n, numbers; %, percentage.
*$p < 0.05$.
[a]t, independent t-test.
[b]χ^2, chi-square test.

Predictors of FD

Results from chi-squared test employed in the univariate analysis showed 19 potential predictors of FD, including disease at birth, frequent constipation, frequent diarrhea, frequent food allergy under CHILD sub-theme; time of introducing complementary food, food preparing under FOOD sub-theme; anxiety, quarrels, parenting style, time for parenting company under PARENT sub-theme; and observing hunger and satiety signals, training of self-feeding, luring to eat, forcing to eat, allowing playing during mealtime, interacting with child during mealtime, providing fixed table, providing exclusive tableware, quiet environment under FEEDING PRACTICE sub-theme. Detailed results are shown in Table 2.

Results from adjusted binary logistic regression employed in the multivariate analysis selected 10 out of 19 independent preditors of FD. Among them, 6 were risk factors including frequent constipation ($OR = 1.603$, $CI = 1.006–2.555$) from CHILD; anxiety ($OR = 4.322$, $CI = 3.074–6.079$) and indulgent parenting style ($OR = 2.108$, $CI = 1.306–3.405$) from PARENT; luring to eat ($OR = 2.806$, $CI = 2.000–3.937$), forcing to eat ($OR = 2.040$, $CI = 1.407–2.958$), and allowing playing during mealtime ($OR = 2.023$, $CI = 1.435–2.853$) in FEEDING PRACTICE, and 4 of them protective factors including food preparing ($OR = 0.586$, $CI = 0.385–0.891$) in FOOD; observing hunger and satiety signals ($OR = 0.667$, $CI = 0.457–0.974$), interacting with child during mealtime ($OR = 0.505$, $CI = 0.308–0.828$), as well as providing exclusive tableware ($OR = 0.370$, $CI = 0.191–0.719$) in FEEDING PRACTICE. The results are summarized in Table 3 and illustrated in Figure 2.

Discussion

Children are supposed to develop self-feed skills in their first 2 years of life, while 6–24 months of age is the most critical period for children to form appropriate eating behaviors (16). During this stage, young children's eating problems can easily provoke parents' anxiety, and parents faced with FD are more likely to experience stress and helplessness, so professional advice and guidance are in urgent demand among them. Given that, we conducted this multi-center cross-sectional study to explore the prevalence and predictors of FD in young children at this problem-prone stage, in the hope of offering some enlightenment on the prevention of FD.

Current prevalence of FD in young children worldwide

Recent studies abroad have reported FD prevalence ranging from 25% to 50% in young children (7–9), while among those suffering from growth retardation or diseases such as autism,

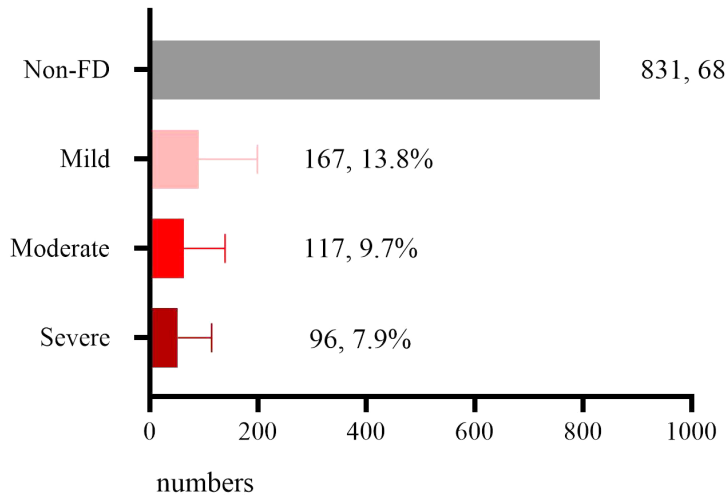

FIGURE 1
Prevalence of FD in children at self-feeding transition stage.

the prevalence can get as high as 80% (17, 18). In 2013, Zhao et al. (14) carried out an epidemiological survey on FD prevalence in young children aged 6–24 months in 69 maternal and child health care hospitals in China, in which a total of 4,017 participants were investigated and the FD prevalence was 21.4%. In our study, we found an FD prevalence of 31.4% for children aged 6–24 months, which was within the range of previous foreign studies (7–9), but higher than reported in Zhao's et al. (14) study, revealing a possible increasing of FD prevalence in China. However, it is also worth noting that the FD prevalence in young children appears to be rising both in the domestic and abroad. A nationwide prevalence study in USA has reported that the FD prevalence in young children presented an ascending trend over a 5-year period from 2009 to 2014, suggesting that FD has gradually become a common issue in pediatric clinic (19). We reckon this trend may have been caused by a series of multi-factors related to social development, and here we offer a possible speculation that may interpret the underlying mechanism: With a rapid economic growth, the birth rate has gradually decreased while the population education level has been continuously improved. With fewer children in one family, parents tend to contribute more to parenting, and regard child-raising as a more elaborate job. Once meticulous feeding becomes ubiquitous, feeding problems emerge in large numbers. As is the case with China, although the government has recently released the three-child policy, many urban young parents still choose to raise only one child for the time being, and this may lead to parents' extra focus on children's eating problems, which is not conducive to the forming of proper eating behaviors. Nevertheless, what has mainly caused this apparent increasing trend of FD prevalence in young children worldwide is not yet completely determined, due to the heterogeneous definitions and evaluation methods adopted by various studies, and further evidence is needed to prove our theory stated above.

Independent predictors of FD

Our study included 27 potential predictors grouped by four sub-themes, from which we derived 10 independent predictors of FD, including 4 protective predictors and 6 risk predictors.

Protective predictors

As one of the protective predictors, food preparing was the only one proved to be an independent predictor of FD from FOOD sub-theme. As for other food-related factors, previous researches have studied whether exclusive breastfeeding and time of introducing complementary food are associated with FD, but have acquired seemingly controversial results. In this study, we did not observe any differences in FD in children who were breastfed. Similarly, De Barse et al. (20) found children who were never breastfed did not differ in selective eating frequency from children breastfed for 6 months or longer. However, it is generally believed that exclusive breastfeeding can reduce the risk of FD, as various flavors of breast milk make exclusive-breastfed children more likely to accept different types of complementary foods (21). Besides, we did not observe any differences in FD in children who were introduced with complementary food <4, 4–6 or >6 month, but Hollis et al. (22) found that complementary food introduction after 6 months could reduce the risk of FD compared with that between 4 and 6 months, whereas De Barse et al. (20) suggested that introduction of vegetables into children's diet before 5 months might contribute to lower FD risk. Due to the lack of sufficient evidence in existing studies to demonstrate the relationship between breastfeeding, complementary feeding time and feeding difficulties, it is recommended that future studies would further confirm this issue through evidence-based methods. In the final adjusted regression, the results showed that among all the food-related

TABLE 2 Potential predictors associated with FD in the univariate analysis.

Categories	Variables	FD ($n = 380$)	Non-FD ($n = 831$)	χ^2	p
Child	Gestational age (n, %)				
	≤37 weeks	74 (19.5)	157 (18.9)		
	>37 weeks	306 (80.5)	674 (81.1)	0.057	0.811
	Weight at birth (n, %)				
	<2,500g	91 (23.9)	174 (20.9)		
	≥2,500g	289 (76.1)	657 (79.1)	1.391	0.240
	Disease at birth (n, %)				
	Without	338 (88.9)	776 (93.4)		
	Asphyxia	27 (7.1)	32 (3.9)		
	Digestive disease	5 (1.3)	3 (0.4)		
	Endocrine diseases	7 (1.8)	16 (1.9)		
	Cardiovascular disease	3 (0.8)	4 (0.5)	10.262	0.036*
	Frequent constipation (n, %)				
	No	308 (81.1)	762 (91.7)		
	Yes	72 (18.9)	69 (8.3)	28.717	0.000***
	Frequent vomiting (n, %)				
	No	343 (90.3)	757 (91.1)		
	Yes	37 (9.7)	74 (8.9)	0.217	0.642
	Frequent diarrhea (n, %)				
	No	345 (90.8)	803 (96.6)		
	Yes	35 (9.2)	28 (3.4)	18.040	0.000***
	Frequent food allergy (n, %)				
	No	307 (80.8)	770 (92.7)		
	Yes	73 (19.2)	61 (7.3)	37.334	0.000***
	Cow's milk protein allergy (n, %)				
	No	318 (83.7)	728 (87.6)		
	Yes	62 (16.3)	103 (12.4)	3.407	0.065
Food	Exclusive breastfeeding (n, %)				
	No	58 (15.3)	164 (19.7)		
	Yes	322 (84.7)	667 (80.3)	3.483	0.062
	Time of introducing complementary food (n, %)				
	<4 month	11 (2.9)	4 (0.5)		
	4–6 month	133 (35.0)	302 (36.3)		
	>6 month	236 (62.1)	525 (63.2)	12.440	0.002**
	Food preparing (n, %)				
	No	109 (28.7)	112 (13.5)		
	Yes	271 (71.3)	719 (86.5)	40.416	0.000***
Parent	Anxiety (n, %)				
	No	114 (30.0)	576 (69.3)		
	Yes	266 (70.0)	255 (30.7)	164.414	0.000***
	Quarrels (n, %)				
	No	229 (60.3)	717 (86.3)		
	Yes	151 (39.7)	114 (13.7)	103.265	0.000***
	Parenting style (n, %)				
	Responsive	132 (34.7)	440 (52.9)		
	Controlling	143 (37.6)	302 (36.3)		
	Indulgent	87 (22.9)	63 (7.6)		
	Neglectful	18 (4.7)	26 (3.1)	69.651	0.000***
	Time for parenting company (n, %)				
	<4 h/day	86 (22.6)	202 (24.3)		
	4–8 h/day	108 (28.4)	239 (28.8)		
	8–12 h/day	100 (26.3)	152 (18.3)		
	>12 h/day	86 (22.6)	238 (28.6)	11.907	0.008**
Feeding practice	Observing hunger and satiety signals (n, %)				
	No	125 (32.9)	143 (17.2)		

(*Continued*)

TABLE 2 Continued

Categories	Variables	FD ($n = 380$)	Non-FD ($n = 831$)	χ^2	p
	Yes	255 (67.1)	688 (82.8)	37.234	0.000***
	Training of Self-feeding (*n*, %)				
	No	170 (44.7)	258 (31.0)		
	Yes	210 (55.3)	573 (69.0)	21.386	0.000***
	Luring to eat (*n*, %)				
	No	157 (41.3)	648 (78.0)		
	Yes	233 (58.7)	183 (22.0)	157.272	0.000***
	Forcing to eat (*n*, %)				
	No	242 (63.7)	726 (87.4)		
	Yes	138 (36.3)	105 (12.6)	91.154	0.000***
	Allowing playing while eating (*n*, %)				
	No	179 (47.1)	624 (75.1)		
	Yes	201 (52.9)	207 (24.9)	91.412	0.000***
	Interacting with child while eating (*n*, %)				
	No	82 (21.6)	79 (9.5)		
	Yes	298 (78.4)	752 (90.5)	32.968	0.000***
	Between-meal nibbles (*n*, %)				
	No	179 (47.1)	393 (47.3)		
	Yes	201 (52.9)	438 (52.7)	0.004	0.952
	Meal time limit (*n*, %)				
	No	259 (68.2)	586 (70.5)		
	Yes	121 (31.8)	245 (29.5)	0.688	0.407
	Providing exclusive tableware (*n*, %)				
	No	89 (23.4)	102 (12.3)		
	Yes	291 (76.6)	729 (87.7)	24.389	0.000***
	Providing fixed table or chair (*n*, %)				
	No	44 (11.6)	26 (3.1)		
	Yes	336 (88.4)	805 (96.9)	34.188	0.000***
	Quiet environment (*n*, %)				
	No	112 (29.5)	68 (8.2)		
	Yes	268 (70.5)	763 (91.8)	93.407	0.000***
	Eating with parents (*n*, %)				
	No	171 (45.0)	378 (45.5)		
	Yes	209 (55.0)	453 (54.5)	0.025	0.874

FD, feeding difficulty; χ^2, chi-square test; *n*, numbers; %, percentage.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

TABLE 3 Independent predictors associated with FD in multivariate logistic regression analysis.

Category	Variables	*B*	S.E.	Wald	*p*	*OR* (95% CI)
Child	Frequent constipation	0.472	0.238	3.937	0.047*	1.603 (1.006, 2.555)
Food	Food preparing	−0.535	0.214	6.244	0.012*	0.586 (0.385, 0.891)
Parent	Anxiety	1.464	0.174	70.784	0.000***	4.322 (3.074, 6.079)
	Indulgent parenting style	0.746	0.245	9.3.5	0.002**	2.108 (1.306, 3.405)
Feeding practice	Observing hunger and satiety signals	−0.405	0.193	4.386	0.036*	0.667 (0.457, 0.974)
	Luring to eat	1.032	0.173	35.658	0.000***	2.806 (2.000, 3.937)
	Forcing to eat	0.713	0.190	14.146	0.000***	2.040 (1.407, 2.958)
	Allowing playing while eating	0.705	0.175	16.160	0.000***	2.023 (1.435, 2.853)
	Interacting with child while eating	−0.683	0.252	7.336	0.007**	0.505 (0.308, 0.828)
	Providing exclusive tableware	−0.993	0.338	8.629	0.003**	0.370 (0.191, 0.719)

After corrected with "Maternal age, Complication of pregnancy and Household monthly income per capita" from demographic characteristics data. FD, feeding difficulty; OR, odd ratio; CI, confidence interval.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

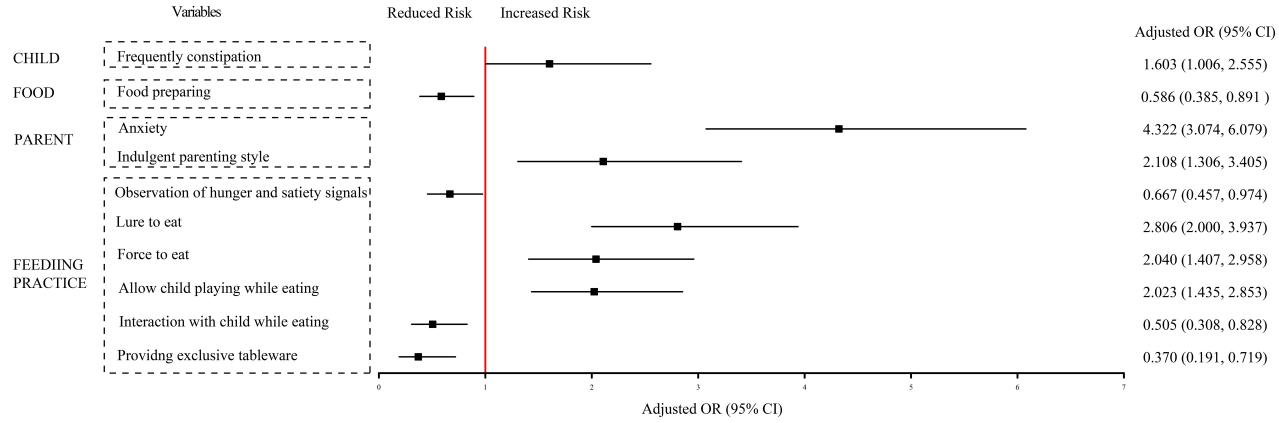

FIGURE 2
Independent predictors associated with FD in multivariate logistic regression analysis. After corrected with "Maternal age, Complication of pregnancy and Household monthly income per capita" from demographic characteristics data. FD, feeding difficulty; OR, odd ratio; CI, confidence interval.

potential factors, only food preparing was proved to be an independent protective predictor. Children at self-feeding transition stage are supposed to experience foods with different textures and multiple flavors, and the most effective way to prevent FD is simply for parents to attentatively prepare food for their young children. Practical strategies of food preparing in the purpose of improving children's appetite include: investigating children's food preferences, providing them with food of age-appropriate textures, alternating cooking methods, selecting food with adorable shapes, as well as adding in seasonings properly. Furthermore, frequent exposure to new foods, and allowing touching and playing with all varieties of foods might improve children's acceptance of whatever they are feeding.

In FEEDING PRACTICE, protective predictors include observing hunger and satiety signals, interacting with child during mealtime and providing exclusive tableware, which suggest that accurate capture of hunger and satiety signals, positive parent-child interaction during mealtime, and provision of exclusive tableware can reduce the risk of FD. Similar results were found in research conducted by Atzaba-Poria et al. (23) that more intimate parent-child interaction during mealtime leads to a lower chance of FD. Van Den Engel-Hoek et al. (24) stated in their study that inappropriate eating behavior was reduced proportionally to the children's learning development of utilizing feeding equipment.

As far as we are concerned, prevention is of much greater importance than treatment, and understanding these protective factors will help child health care clinicians and pediatricians guide parents to prevent FD from young children effectively in their routine work. Thus, we highlight the significance of health education to parents, and here we offer some important feeding practices as showed in **Figure 3**.

Risk predictors

We present 6 risk predictors of FD here, with 1 from CHILD, 2 from PARENT and 3 from FEEDING PRACTICE.

Among child-related factors, long-term frequent constipation appears to increase the risk of FD. As far as we know, no similar conclusion has been drawn in relevant studies. One possible explanation is that long-term frequent constipation is related to gastrointestinal dysfunction which causes physical discomfort, making it difficult for parents to feed their children. As for the remaining factors, some believe that premature birth and other diseases may be correlated with FD, probably due to the fact that children under these conditions almost always enjoy more tolerance from their parents, thus developing inappropriate eating behaviors. However, Sanchez et al. (25) found that no difference was shown in eating behaviors at the age of 3 years between preterm and full-term infants, which to some degree is consistent with our results that preterm birth showed an inadequate relationship with FD. Whether premature birth and other disease conditions are risk predictors of FD are still undefined according to existing literature.

Normally it is parents who decide when, where, what and how much their children are fed, so parents have a crucial impact on children's eating behaviors. Consistent with most of the previous studies (3, 26–28), our results suggested that anxiety is the main risk predictor of FD among parents-related factors. In fact, more than 50% of parents in our study believed that their children had various feeding problems (2, 3), and more than one third of parents expressed concern about feeding processes (28). Anxiety seems to be an unavoidable problem in child-raising. Although no studies have yet been able to construct a complete model describing the complex relationship between parental anxiety and FD, reasonable interpretations and explanations about it have been made. For instance, the correlation between parental anxiety and FD in children was well illustrated in a study which suggested that children's food aversion and refusal behaviors could be affected by tense parent-child interactions during mealtime due to parental anxiety (26). Moreover, Lee et al. (28) found that anxious parents who tend to excessively focus on their children's diet and eating behaviors are prone to adverse feeding strategies such as forced feeding, which makes their children resist eating and thus complete the vicious circle of parental anxiety and FD. In cases where parents

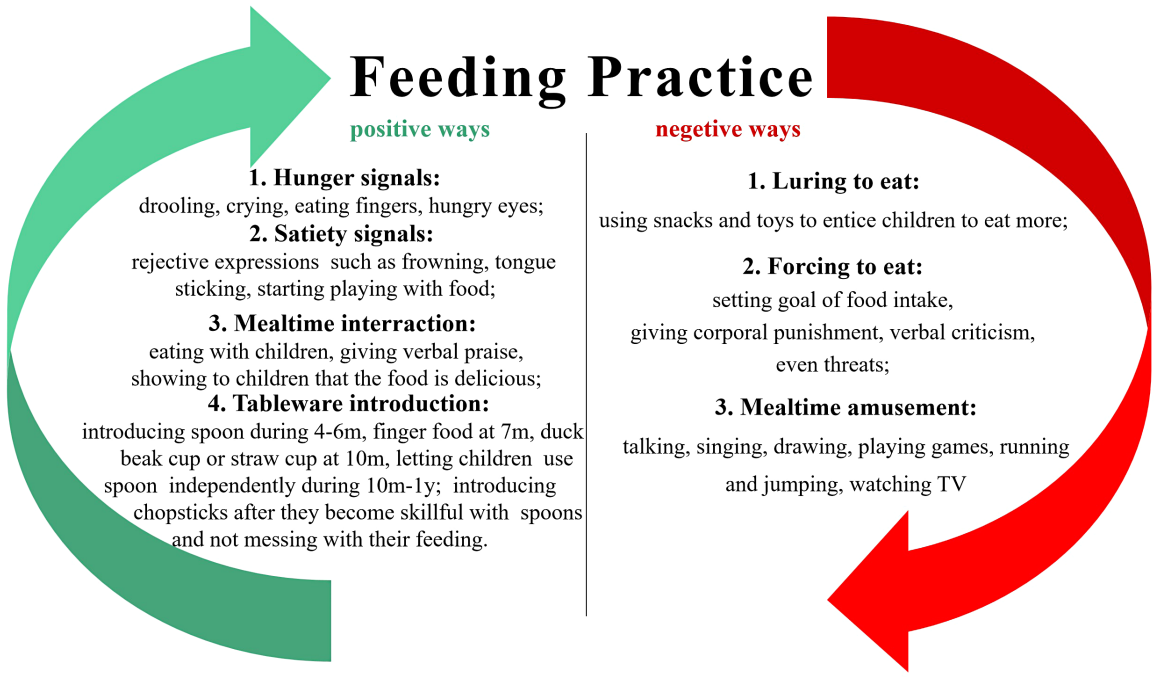

FIGURE 3
Highlights in feeding practice.

are under extreme anxiety, detailed guidance from pediatricians is very necessary. Clarifying the pathogeny of FD and offering specific suggestions can be of paramount importance to help parents reduce anxiety, and it also turn out an effective way to try to shifting their attention from temporal figures such as children's weight gains and food intake to something of practical significance (29). For instance, pediatricians can advise parents to start from enhancing children's activities or preparing food.

Another parent-related risk predictor of FD revealed by our study is indulgent parenting style. Previous literature has identified that 81.2% of parents reported non-responsive feeding style (28), one of the major risk predictors of FD (30, 31), while our study suggested indulgent parenting style to be the most adverse. In China, most children born between 1980s and 1990s are the only children in their families. Now these children have reached childbearing age and their parents have approached retirement, which generates the special intergenerational structure of "4 + 2 + 1" in most urban families. Being the only one of the third generation in a family, the young grandchild at the bottom rank of this inverted triangle family structure is naturally favored since born, and in many cases raised by grandparents rather than its own parents. Thus, indulgent feeding style is ubiquitous in these families. When treating these young parents with their own only child from this special family structure, timely and correct guidance from pediatricians on their feeding practice is most crucial, because it is they who should be encouraged to play a leading role in the parenting process instead of their child's grandparents.

Our study also found that factors including luring to eat, forcing to eat and allowing playing during mealtime are also risk predictors of FD from the FEEDING PRACTICE sub-theme. Luring to eat and allowing playing during mealtime are seemingly effective ways to increase children's food intake by diverting their attention, such as inducing children to eat more food using snacks, allowing children to watch animations while feeding, etc. Typical performances can be seen in **Figure 3**. However, since children's adulthood eating habits can be adversely impacted, these approaches are not recommended by us. It's also worth noting that it is very easy to cause airway foreign bodies by making children laugh during mealtime, and pediatricians are obliged to correct inappropriate and dangerous feeding practice of parents. Besides, forcing to eat seems to be a common practice in China, where grandparents or parents are excessively concerned about children's food intake, and those suffering from serious parental anxiety even do not allow leftovers (14). This kind of compulsive behavior can make children resistant to eating. The more proper way to do this is to limit the mealtime within 25–30 min (7, 8), and what parents need to do most is to create a harmonious atmosphere for eating and to provide children with age-fit food as well as exclusive tableware. As for how much to be fed, it should be and will be dependent on children themselves only.

Strengths and limitations

6–24 months of age is the most critical period for children to form appropriate eating behaviors. This study is one of the few that focuses on exploring the prevalence and potential predictors of FD in young children during this period. Both protective and risk factors from comprehensive perspectives have been analyzed. Our results serve as enlightenment and provide strong support

for child health care clinicians and pediatricians to guide parents on how to prevent FD. Admittedly, limitations existed as follows. Firstly, an overview concerning our research objects (FD parents and children) is not available in rural areas since research centers are all located in urban areas, regional restrictions thus were inevitable. Secondly, this study involves five research centers. Although these five hospitals are located in the same city, and the response effective rate is similar between each research center, there may be some differences in the demographic characteristics of patients between each research site, which was not discussed in depth in this study. Finally, the measurement in this study as Potential Predictors of FD Questionnaire was developed by the researcher, and have not been tested for validity. Future study are recommend to develop a well-structured and valid scale to assess the associated factors of FD.

Conclusions

This is a multi-center cross-sectional study on the prevalence and predictors of FD in children at self-feeding transition stage in China. The results showed that the prevalence of FD in young children was 31.4% presenting an ascending trend with time, and meticulous feeding lead to parental excessive concern about children's feeding issues is the main reason behind this. We identified 10 independent predictors of FD, including food preparing, observing hunger and satiety signals, interacting with child during mealtime, providing exclusive tableware as protective factors, while frequent constipation, parental anxiety, indulgent parenting style, luring to eat, forcing to eat, allowing playing during mealtime as risk factors. Our study advocates that child health care clinicians and pediatricians ought to attach more attention to the prevention of FD in young children. They are obliged to correct improper feeding strategies of caregivers in time, and ensure that they feed their children correctly under guidance. Most importantly, feeding guidance keeping up with the times needs continuous developing and updating.

Keynotes

- There appeared to be an increasing trend of FD prevalence with 31.4% in China which might be linked with social and economic development.
- 6 risk factors and 4 protective factors were determined associated with FD in children at self-feeding transition stage.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Western China Women's and Children's Hospital of Sichuan University (West China Second University Hospital, Sichuan University). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

Study concept and design: MT and XL; acquisition of data: MT and XL; analysis and interpretation of data: MT; drafting of the manuscript: MT and XL; statistical analysis: MT; administrative, technical, and material support: FY; study supervision: FY. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Healthy helpers: using culinary lessons to improve children's culinary literacy and self-efficacy to cook

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Background: Children do not eat the recommended amounts of vegetables, and school-based nutrition education has not been found to impact this behavior. Cooking education is associated with improved children's culinary literacy (CL) and eating behaviors. This study investigated the impact of a culinary literacy (CL) curriculum on children's acceptance of vegetable-added (mushrooms) recipes, CL, self-efficacy to cook (SE), and willingness to try vegetables (WV).

Methods: A convenience sample of 39 fourth and fifth graders were exposed to a six-lesson virtual CL curriculum that taught basic cooking skills and how to prepare six recipes, including three traditional recipes and the same recipes with added vegetables.

Results: Children who participated in the CL curriculum accepted vegetables added to pizza pockets, but vegetables added to macaroni and cheese and fajitas negatively affected the acceptance of recipes. Children improved their CL and SE but did not show a significant change in their WV.

Conclusion: Findings suggest that CL programs focusing on vegetables may drive factors associated with dietary behavior change, SE, and acceptance of vegetables. Future studies should consider CL as a potential method to improve vegetable intake in children in tandem with nutrition education or as a sole intervention. The study was limited by its small sample size, the virtual setting, and the use of mushrooms as the primary vegetable source. Future studies should be conducted with a larger sample size, in a traditional classroom setting, use a variety of vegetables, and collect qualitative data on the sensory characteristics affecting children's WV.

KEYWORDS

self-efficacy, culinary literacy, vegetable intake, cooking skills, children, culinary knowledge, recipe acceptance, willingness to eat vegetables

1. Introduction

Childhood is a critical time for establishing healthy lifelong eating habits and dietary behaviors that often continue into adolescence and adulthood (1). A well-balanced diet containing adequate amounts and varieties of fruits and vegetables is necessary for children to maintain appropriate caloric intake and body weight, support nutrition adequacy, and reduce the risk of chronic disease (2). Despite the established health benefits, children continue to fall short of the daily recommended intake of 2–4 cups of total fruits and vegetables, as outlined in the Dietary Guidelines for Americans 2020–2025 (3, 4). Suboptimal intakes in children predict poor fruit and vegetable intakes as they age and progress into adolescence and adulthood (2, 4, 5). The disproportionately substandard produce intake among lower-income families is even

more troubling, as is lower intakes of vegetables when compared to fruit (5, 6). Previous research on children's fruit and vegetable intakes and interventional programs have been broad and did not focus solely on vegetables or explore the role cooking education and experiences may have on culinary literacy, self-efficacy to cook and children's acceptance and willingness to try recipes with vegetables, the focus of this study.

To successfully increase children's vegetable intake, it is important to address barriers that impact access and acceptance of this food group. Two barriers to children's acceptance of vegetables are their unfamiliarity to the child and dislike of how they taste (5, 7, 8). The high cost of vegetables is an added familial barrier (5, 9). School-based programs have been tasked to address these barriers, with most focusing on educating children and families about health benefits and/or providing free/subsidized fruits and vegetables. However, awareness of health benefits does not address the acceptance of produce, and programs have reported no significant effects on vegetable intakes (6). Research has suggested that school programs may be more effective by directly addressing children's familiarity to vegetables and their taste (8, 10). Previous research has achieved this by providing children with regular small tastings, hiding vegetables in meals, or serving them in an identifiable form (8, 10, 11). Another method to employ these strategies of familiarizing children to vegetables in the school environment could be to create an intervention centered around promoting culinary literacy (CL), the set of abilities that allow individuals to prepare meals from scratch.

Cooking behaviors/frequency and CL among young children and families is an emerging area of study with the potential to improve eating behaviors, including the increased consumption of produce (11–13). Studies focusing on cooking behaviors find that with the decline in fruit and vegetable intake, there is also a concurrent decline in home cooking and CL levels among adults (12, 14, 15). The relationship between CL and nutrition is multigenerational. As home cooking declines, culinary knowledge, and skill development decrease among younger generations due to limited exposure to culinary processes and a lack of adult/peer modeling. This has resulted in low cooking collective efficacy among the entire family unit (12, 16). Higher CL and increased home cooking frequency have been linked to improved dietary quality as home-cooked meals have been found to naturally contain more fruits and vegetables compared to pre-prepared meals (13, 14). More interventions to promote vegetable intake among children must examine the connection between CL, improved cooking self-efficacy, and dietary behavior changes.

Interventions that feature experiential learning like cooking are unique in that they provide hands-on activities that require active participation and multisensory experiences (17, 18). Children learn about the world through their senses and interacting with vegetables may reduce the initial apprehension they might feel toward new foods. Children often hesitate to try new foods like vegetables, resulting in inadequate intake (19). They should interact with vegetables to reverse this trend. Involving children in the kitchen and having them prepare recipes that feature fresh produce provides direct contact, increased familiarity, and repeated taste exposures to vegetables. Research has reported that these factors have been related to increased self-selection of produce by children (11, 14). Offering experiential learning through cooking in the school environment provides knowledge with an accompanying skill set and may have a greater influence on their intake of vegetables (1, 11). Beyond their experiential nature, culinary education programs are social and allow for ownership and empowerment and have been linked to improved nutrition-related beliefs, self-efficacy, knowledge, and behaviors (15, 16). However, many research interventions that focused on child involvement in meal preparation were part of a multicomponent program or folded in other food literacy topics such as nutrition education and gardening. The multicomponent aspect of these programs made it difficult to parse out which programmatic components led to behavior change. Lack of focus on CL behaviors may account for limited gains in knowledge and skills among participants (18, 20, 21). This study is novel as the singular focus is on CL behaviors as drivers of behavior and self-efficacy change that may result in willingness to try vegetables.

Previous efforts to increase vegetable intake among children, particularly those within the school setting, have failed to elicit enhanced vegetable intake, and novel approaches are needed. This study examined the effect of a school-based CL program that featured at-home cooking experiences on children's acceptance of vegetable-added recipes and willingness to try vegetables without direct nutrition education. The results of this study will add to the body of research emerging about best practices to encourage children from lower-income families to eat more vegetables, achieve recommended vegetable amounts, and improve the nutrition behavior drivers of culinary knowledge and self-confidence/efficacy in the life skill of cooking.

2. Materials and methods

2.1. Participants

Participants were a convenience sample of children in a health/physical education class at a Charter School in an urban area of New Jersey. Approximately 82% of children received free/reduced school lunches. Children of all genders and demographics were eligible to participate if they were in fourth or fifth grade, had written parental/guardian consent to participate in the study, had no medical or behavioral aversion to taste the foods, had access to a computer with video for Zoom® sessions and survey completion, and could speak or understand English or Spanish at a proficient level. The Rutgers University Institutional Review Board reviewed and approved the study protocol.

2.2. Description of the intervention program

The *Healthy Helpers: Culinary Literacy for Kids* research study used a 6-week curriculum to teach elementary-aged children CL, including basic cooking skills and concepts. The curriculum design was informed by the Social Cognitive Theory (SCT), which claims that behavior change results from factors such as self-efficacy and experiential learning. Lessons and activities were inspired by existing food literacy curricula, specifically Cooking Matters and In Defense of Food (21–24). The curriculum was developed and reviewed by a registered dietitian with a doctorate in nutrition psychology, a Registered Dietitian Nutritionist (RDN) specializing in community nutrition, a clinical RDN, and a former classroom educator with a doctorate in education. An RDN taught one weekly lesson, and the

children's physical education teacher supervised the classes. The original program design was to teach lessons during the regularly scheduled school day. Due to safety precautions surrounding the COVID-19 pandemic, lessons were revised to be taught virtually via the online platform Zoom®, and surveys were collected via the online survey tool, Qualtrics®. Lessons were taught, and data were collected during March and April 2021. Each lesson featured a cooking concept or skill followed by a recipe cooking demonstration. Cooking skills promoted cooking techniques and strategies for children to perform the skill independently, such as grating cheese using a box grater, using scissors to cut, safe knife handling, and using the microwave safely. Cooking demonstrations featured recipes in a traditional form familiar to the children or in a version that included mushrooms (Supplementary Table 1). Mushrooms were chosen as the added vegetable as they have the unique quality of taking on the flavor of the ingredients they are combined with, do not impart a bitter taste, are not a common food allergen, and are readily available in many forms, including fresh, frozen, and canned (22, 23). Recipes were randomized to limit order bias using a Latin square design. All recipes can be found in the Supplementary Material.

Participating children were provided weekly cooking kits at no cost to the family to encourage participation and decrease the economic burden of cooking activities. Each kit contained a printed copy of the weekly recipe and all the ingredients required for that week's recipe. Children received their kits as part of their pre-existing weekly school meal pickups. Cooking kits did not contain kitchen tools since program recipes were designed only to require the equipment and tools commonly found across all socioeconomic households (microwave, measuring spoons, utensils, scissors, and a grater) (24). To ensure that families had what they needed to complete the cooking assignments, participants were told that they could request any missing pieces of kitchen equipment required for the recipes. No requests for additional equipment were made.

After viewing the weekly live lesson via Zoom®, children replicated that week's cooking demonstration at home using the cooking kits independently or with familial support. Children had until the following week's class to complete their home cooking assignment. After cooking the weekly recipe, children were asked to take a picture of their dish, taste the food product prepared, and complete the online Post Recipe Acceptability Survey (PRAS) with eight questions to assess the acceptability of the recipe. Children were sent regularly scheduled reminders by the RDN and physical education teacher via the existing Google Classroom site and were instructed to follow the recipe exactly as written. As backup instruction, a YouTube link to the cooking demonstration video shown in class was provided to each child for reference. The cooking demonstration videos and recipes were provided in English and Spanish for bilingual households.

2.3. Survey instruments, measures, procedures, and data analysis

We collected data via two validated survey that were informed by research and expert reviewed via the online survey platform Qualtrics®: the PRAs and the Culinary Literacy Survey (CLS). Each child completed the PRAS after completing each of the six at-home cooking assignments, and the CLS was completed by each child at baseline and post-program (Figure 1). All surveys are available in the Supplementary Material.

2.3.1. Post recipe acceptability survey

An eight-item quantitative survey was administered to each child after they made and tasted each of the six recipes to assess the acceptance of each recipe. Acceptability was based on the child's liking of the food, their desire to eat it again, their desire to cook the recipe again, and whether they would choose the food if it were offered at school lunch. Answers of "no" were coded as 1, and answers to "yes" were coded as 2. Therefore, the minimum acceptability score was 1, and the maximum score was 2. The coded responses to the Post recipe acceptability survey (PRAS) were aggregated and averaged into a total acceptability score for each of the six recipes tested.

2.3.2. Culinary literacy survey

The Culinary literacy survey (CLS) was administered in a quasi-experimental, pre-post survey design to assess fourth and fifth grade children's CL skills. Questions in the CLS were derived from the Tool for Food Literacy Assessment in Children (TFLAC) validated survey to assess culinary literacy knowledge, self-efficacy to perform basic cooking tasks, and overall willingness to eat vegetables (25).

2.3.3. Variables and data analysis

Post hoc power analysis was conducted using SPSS, version 27, to test the difference between paired sample group means using a two-tailed test with a medium effect size (d = 0.50) and an alpha of 0.05. Results showed with the criteria stated above, our sample of participants would achieve a power of 0.80. Recipe acceptance scores were calculated by adding the answers to four questions and taking the mean score (Yes-2, No-1): Did you like the recipe? Would you eat it again? Would you make it at home if you had everything you need and the help of an adult? Would you eat this food if it was offered at school lunch? The maximum recipe acceptance score was 2, yes to all four questions, and the minimum recipe acceptance score was 1, no to all four questions. Paired t-tests were performed on data collected from the PRAS to determine if there was a significant statistical difference in recipe acceptance scores of traditional vs. vegetable-added recipes.

Quantitative data collected on the CLS were classified into three subcategories: (1) culinary literacy knowledge (CL); (2) self-efficacy to perform basic cooking tasks (SE); and (3) willingness to eat vegetables (WV). Child responses were coded with 0 indicating incorrect answers/negative responses and 100 indicating correct answers or the most positive responses. The minimum scores in each area were 0, and the maximum was 100. After calculating each child's score, descriptive statistics were used to calculate the mean and standard deviation for each of the three variable subcategories. A total score for CLS was calculated by taking the mean of all three subcategory scores and the standard deviation of the total score mean was presented. We addressed missing data by imputing the series mean for 25% of the missing values. Paired *t*-tests were used to determine if there was a significant statistical difference in the means of pre- and post-scores on the CLS survey for the three dependent variables (CL, SE, WV) and total survey score.

3. Results

Children participating in the *Healthy Helpers: Culinary Literacy for Kids* program had improved outcome measures that may predict improved vegetable intakes among this population. Of the three

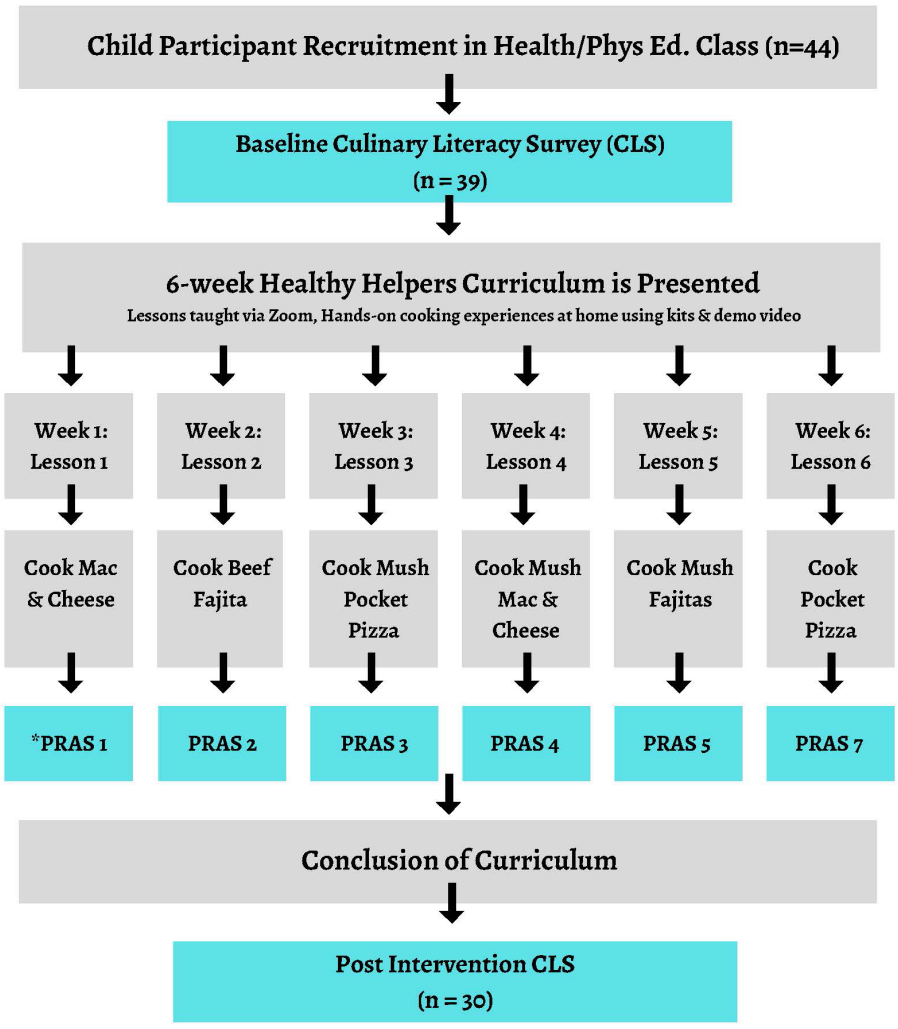

FIGURE 1
Sequence of participation in Healthy Helpers; Culinary Literacy for Kids Curriculum and Survey collection. PRAS, Post recipe acceptance survey.

recipes tested, children best accepted added vegetables as pocket pizzas. Added vegetables to macaroni and cheese and fajitas negatively influenced children's acceptance of these recipes. Participation in the curriculum improved nutritional behavior drivers. These included significantly increasing children's culinary self-efficacy and culinary literacy knowledge. We did not observe increased measures assessing children's willingness to eat vegetables (Supplementary Table 4).

3.1. Participant demographics

Forty-four parents/guardians consented for their children to participate in this study. Of the consented children, 39 (89%) completed the CLS pre-intervention, and 30 (68%) completed the survey post-intervention. The mean age of the children was 10.6 (SD 0.6) years old, with the majority being female (59%). Most children were Hispanic (87%) and were receiving free and reduced breakfast/lunch (82%; Supplementary Table 2).

3.2. Child acceptance of traditional vs. added-vegetable recipes

To test the hypothesis that there would be no significant difference in children's acceptance of recipes with and without vegetables, we examined paired *t*-tests for a significant statistical difference between recipe pairs, i.e., traditional recipes and the same recipe with added vegetables. There was no statistical difference between the children's acceptance of the traditional and mushroom pocket pizza recipes [$t(9)=0.712$, 0.494]. We found a significant difference between the children's liking of the traditional macaroni and cheese and the recipe with increased vegetables [mushroom macaroni and cheese; $t(12)=3.600$, 0.004]. We also found a significant difference in the children's acceptance of the traditional beef fajita recipe and the fajita with added vegetables (portabella fajita) with children preferring the beef fajita [$t(14)=2.739$, 0.008]. The children's liking of the pocket pizzas was not affected by adding vegetables; however, vegetables added to macaroni and cheese and fajitas negatively impacted the liking of these recipes (Supplementary Table 3).

3.3. Child culinary knowledge, self-efficacy to cook, and willingness to eat vegetables

To test the hypothesis that CL lessons would improve nutrition behavior drivers in fourth and fifth grade children, we calculated descriptive statistics of mean and standard deviation of pre- and post-CLS scores for each sub-category: children's culinary literacy knowledge (CL), self-efficacy to cook (SE), and willingness to eat vegetables (WV) and for the total survey score (Supplementary Table 4). Paired *t*-tests were used to determine if there was a significant statistical difference between the means of pre- and post-CLS scores for each sub-category and the total survey score. Results of these analyses revealed a statistically significant increase in children's pre-post self-efficacy to cook [$t(38) = -16.064$, $p < 0.001$] and total scores [$t(38) = -8.088$, $p < 0.001$]. There was no significant difference in willingness to eat vegetables pre- and post-CL lessons [$t(38) = -0.168$, $p = 0.437$].

4. Discussion

Children are not consuming enough vegetables and are eating less home-cooked meals (26). This study aimed to determine the role of CL lessons and home cooking experiences on children's acceptance of recipes with added vegetables and self-efficacy to prepare these recipes, without direct nutrition education. Results showed that *Healthy Helpers,* a school-based CL program that featured home cooking experiences, significantly enhanced children's acceptance of vegetable-added recipes and improved children's self-efficacy to cook independently ($p < 0.05$). *Healthy Helpers* was a novel approach to improving children's self-efficacy in CL and acceptance of recipes with added vegetables. These results are consistent with previous research that has connected cooking with improved dietary behaviors (11, 16, 27).

The objectives of this study are unique in that the CL portion of food literacy was parsed out to examine CL factors (basic cooking skills, vocabulary, and safety) that may influence the acceptance of vegetables (mushrooms) in recipes among elementary-aged children from limited-resource families. Outcome measures included children's liking of recipes featuring vegetables, likelihood to eat these foods again, intent to prepare the recipe at home, and likelihood to choose the food when offered on the school lunch menu. This study sought to achieve these objectives by combining pedagogical strategies such as adult and peer modeling to deliver lessons about CL via a digital platform (Zoom®). The results of this study will add to the body of research emerging about best practices to encourage children from lower-income families to eat more vegetables, achieve recommended vegetable amounts, and improve the nutrition behavior drivers of CL and self-confidence/efficacy in the life skill of cooking.

The first objective of this study was to determine if children would be more likely to accept added vegetables to recipes if they were involved in the cooking process. The recipe with added vegetables accepted by children the same as/equal to its traditional version was the mushroom pocket pizza. We propose two explanations for why vegetables may have been best accepted in this recipe. First, the pocket pizza recipe was unique because it was the only recipe to add vegetables (mushrooms) in a preparation that was not visible to the children; they were enclosed within a dough pouch. Second, the strong flavor combinations of marinara sauce, cheeses (mozzarella/parmesan), and spices (basil/oregano) may have masked the presence of the vegetables better than the other recipes. The method of "hiding vegetables" by adding them in ways that maintain the recipe's appearance and overall flavor has been cited by other studies as an effective strategy to enhance vegetable intake among children and should be considered by parents, nutrition practitioners, and schools as a way to improve children's acceptance of recipes containing vegetables (8, 28).

The vegetable chosen for the research design (mushrooms), may account for the children's limited acceptance of the remaining added vegetable macaroni and cheese and fajitas recipes. Mushrooms are a vegetable that may not be readily accepted by some children. A study that analyzed children's vegetable preferences in 2019 revealed that among six common vegetables tested (broccoli, corn, cucumber, mushrooms, potatoes, and sweet peas), mushrooms were the only vegetable rated as "dislike" in the United States (29). In this manner, all three of our recipes were disadvantaged since mushrooms were the vegetable added to all. The macaroni and cheese recipes and fajitas highlighted the mushroom's presence more prominently/than the pocket pizza, which may have contributed to the recipe's lower rating by the children. The questions within the PRAS did not allow us to determine the specific sensory properties that contributed to children's dislike of the recipes, i.e., color, flavors, textures, aroma. Future studies may consider a mixed method model to examine qualitative factors and determine the sensory properties contributing to or detracting from children's acceptance of vegetables.

The second and third objectives of this project were to measure the impact of a CL-focused program on nutrition behavior drivers in children, such as culinary literacy knowledge (CL), cooking self-efficacy (SE), and willingness to eat vegetables (WV). Lesson content and survey methods used in the project were specifically informed by a theoretical framework that explains how an individual learns, the Social Cognitive Theory (SCT). SCT posits that learning is affected by a blend of personal, interpersonal, and environmental factors that interact in a dynamic and ongoing process to influence behavior (26). These features are unique to nutrition education methods that rely on learning via skill-based approaches and are not present among didactic methods. Children may currently elicit low levels of CL due to the absence of experiential learning opportunities in cooking within the two places they learn most: school and home. The *Healthy Helpers: Culinary Literacy for Kids* curriculum was a novel approach to improving children's vegetable intake by increasing their CL and cooking skills, as many school-based nutrition education interventions do not support skill development (30, 31). Children may have the didactic knowledge that vegetables are a healthful and important part of their diet but lack the "culinary tools" necessary to prepare them for themselves or offer cooking suggestions to their caregivers.

One of the key mechanisms described within the SCT is the concept of self-efficacy (SE), which is the belief by an individual that they possess the requisite cognitive abilities, motivation, and resources to complete the task (32). The SCT states that self-efficacy plays a significant role in motivating an individual to change behavior and is best developed by providing information via different channels, including mastery experiences, collective efficacy, and persuasion (33). Lessons were designed to contribute to children's self-efficacy in cooking by including hands-on experience, skill mastery,

problem-solving strategies, and social interaction (at home and within the virtual classroom).

According to SCT, childhood learning is a remarkably complex process highly influenced by social modeling and persuasion between peers and caregivers. *Healthy Helper's* virtual lessons provided unique opportunities for social modeling in school and home environments, which play a critical role in determining how and what children learn. Peer modeling was incorporated within each lesson by having children share their thoughts during virtual class about culinary concepts and their cooking experiences, which built collective efficacy. Children also had a chance to show their finished dishes to each other by posting pictures of their recipes online. These pictures not only highlighted their accomplishments but also supported their development of self-regulation skills and fosters a sense of ownership, other components of the SCT. In addition, the cooking assignments provided adult/child modeling and persuasion within the home by encouraging caregivers to assist the children in making the recipes. The *Healthy Helpers* cooking experiences got children in the kitchen and encouraged families to prepare nutritious foods from scratch.

Home economics, a course that taught basic food preparation skills and meal planning, is no longer a fixture in school districts. To improve education about food, it may be necessary to bring back some of the concepts taught within a home economics course, such as those included in the *Healthy Helpers* curriculum (34). The *Healthy Helpers* cooking demonstrations and at-home cooking assignments advanced children's behavioral capability to cook, which is another feature of SCT; the provision of tools, resources, and environmental changes that make a new behavior easier to perform. This was accomplished through mastery experiences in cooking and multiple exposures to a vegetable. Cooking also provides repetitive tactile interactions with unfamiliar tools and ingredients. Studies have shown that children who have the opportunity to touch, taste, and smell recipe ingredients, like produce, display fewer food aversions and may eat more of these ingredients (35). By participating in the preparation of six total recipes, children had the opportunity to "master" culinary skills through repetitive practice of basic cooking skills.

The *Healthy Helpers* program successfully increased children's CL and their SE in cooking. The improvements in these two variables may predict future behavior changes surrounding children's intake of vegetables. Similar research has connected enhanced CL and SE to self-selection of produce, improved vegetable intakes, and more home-cooking (18, 27, 36, 37). Improvements in culinary SE are also predictive of a higher frequency of engaging in cooking in the future, as it acts reciprocally to increase a person's desire to repeat the behavior (18, 22, 28, 33). Overall, the short-term changes elicited by the *Healthy Helpers* program (i.e., increased acceptance of food with an added vegetable, increased CL and increased culinary SE) may lead to longer-term behavior changes necessary for increased vegetable intakes.

4.1. Study limitations

Despite the improvement in children's SE to cook, we did not see a significant increase in children's willingness to try vegetables. This outcome was reasonably anticipated for several reasons. The *Healthy Helpers* curriculum consisted of a six-week-long virtual intervention, and its brief timeframe may have decreased the likelihood of substantial behavioral change. While short-term programs like *Healthy Helpers* provide valuable insights, inspiration, and initial momentum, they often fall short when it comes to addressing the range of factors necessary to create significant behavioral change.

The virtual aspect of the program and the lack of in-person instruction/activities also limited our ability to ensure program fidelity. There was no way to ensure that children tasted all the recipes or that they were prepared as intended. For example, in a group discussion, one child shared that they fried the pocket pizza recipe instead of baking it. Another child claimed they did not like mushrooms and intended to leave them out entirely. Altered recipes and procedures may have limited the intervention's ability to provide repeated exposures to mushrooms and taste testing. In fact, there was ultimately no way to ensure that the children, not their caregivers, were responsible for most of the cooking process. These factors are linked to dietary behavior change in the literature. In addition, children might be more willing to try a new food during an in-person class since they are in the presence of their peers during the cooking and tasting process. Virtual learning lacks the in-person observation and social influence/persuasion that in-person cooking classes provide. The virtual aspect of the program may also account for the limited sample sizes as we could not collect surveys in real time and many child participants did not complete or turn in study surveys.

An additional reason we may not have observed a significant increase in children's overall willingness to try vegetables may be linked to the sensory attributes of the vegetable added to recipes (mushrooms). Numerous perceptual features have been related to a child's acceptance or rejection of new foods, including texture, flavor/taste, aroma, and appearance (38). We may have observed little improvement in children's acceptance of recipes and willingness to try vegetables since mushrooms were the only added vegetable in the recipes. As previously stated, some children may have disliked mushrooms' unique characteristics, resulting in a negative response when answering the survey question regarding willingness to try vegetables. Further, since the lessons excluded any nutrition education about mushrooms, children may not have been aware that mushrooms are classified as vegetables, not as fruits or part of another food group. If children did not perceive mushrooms as a vegetable, the survey responses to measure willingness to eat vegetables might not have truly reflected their feelings. We may have observed a greater impact on the acceptability of vegetable-added recipes if recipes featured a larger variety of vegetables that provided different sensory experiences to the children.

5. Conclusion

Children exposed to a 6-week *Healthy Helpers* virtual culinary curriculum combined with hands-on cooking experiences accepted vegetables most readily when they were incorporated into a recipe where the vegetable was hidden and masked by familiar flavors and spices. Post-program measurements showed improvement in children's cooking knowledge and their self-efficacy to cook. School-based nutrition programs should consider incorporating CL and hands-on cooking lessons into existing nutrition education programming. CL may be the missing piece that has prevented other programs or interventions from eliciting significant improvements in children's vegetable intake. Dietary behavior changes often take time.

Longer duration CL programs should be implemented that incorporate repeated exposure to multiple vegetables. While virtual programs have benefits, in-person CL programs are superior in ensuring process fidelity while preparing recipes and tasting finished food products. In addition, measures of children's acceptance of tasted recipes should feature a mixed method model with qualitative testing that allows researchers to examine sensory attributes that were accepted or disliked by children. Finally, future research should include longer-term data collection to examine the sustained impacts of experiential CL programs. Involving children in cooking and improving their CL and SE to cook may be the best way to transform nutrition education into daily food practice.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Rutgers University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

PP conceived and designed the research protocol including survey tools, performed data analysis, and wrote this manuscript in conjunction with other authors. AB assisted in designing the research protocol, including survey tools, submitted and received Institutional Review Board approval from Rutgers University, developed program curriculum and recipes, developed all tables and figures, and wrote this manuscript in conjunction with PP and EC. EC conceived and designed the research protocol including survey tools, assisted in program curriculum development, and wrote or edited this manuscript in conjunction with PP and AB. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1156716/full#supplementary-material

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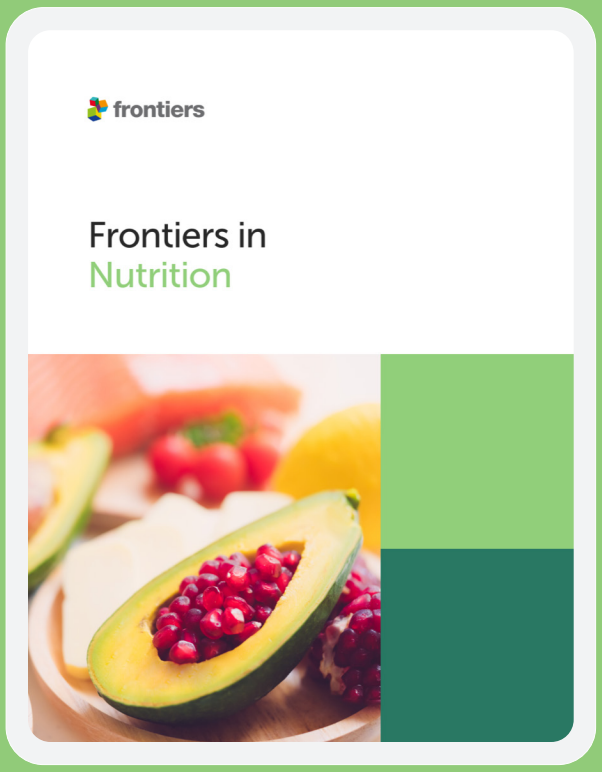

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