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Maternal nutrition literacy and childhood obesity in food-insecure and secure households

Maral Hashemzadeh[1], Masoumeh Akhlaghi[1], Kiana Nabizadeh[1], Asma Kazemi[2]✉ & Hamid Heidarian Miri[3]

This study examined whether maternal nutrition knowledge could help reduce the risk of obesity in children from food-insecure households compared to those from food-secure households. This cross-sectional study was performed on 327 mothers and their children. The children, aged 6–12 years, were recruited from primary schools throughout Shiraz, Iran. Food-insecurity and nutrition literacy were assessed using the Household Food-insecurity Access Scale (HFIAS) and a 60-item Food and Nutrition Literacy Assessment Tool (FNLAT), respectively. Logistic regression models were used to examine the association between children's overweight/obesity and maternal food and nutritional literacy (FNL) across food-secure households and those facing varying degrees of food-insecurity. One hundred thirty-three participants were classified as mild, 28 as moderate, and 7 as severely food-insecure. The results showed that maternal FNL was significantly associated with a reduced risk of overweight/obesity in children (odds ratio (OR) 0.29, 95% confidence intervals (CI) 0.17–0.51). Only moderate/severe food-insecurity was associated with overweight/obesity (OR 4.64, 95% CI 1.75–12.29). Both in food-secure and food-insecure households, good FNL was associated with a significant reduction in overweight/obesity risk compared to poor FNL. The findings suggest that nutrition education programs may be particularly beneficial for children living in food-insecure households, and that these programs should be tailored to address the specific needs of this population.

Keywords Food-insecurity, Food and nutrition literacy, Nutrition knowledge, Childhood obesity, Cross-sectional study, Iran, Health improvement

Abbreviations

CI	Confidence intervals
FNL	Foods and nutrition literacy
FNLAT	Food and Nutrition Literacy Assessment Tool
HFIAS	Household Food-insecurity Access Scale
OR	Odds ratio
SD	Standard deviation

Childhood obesity is a pressing public health concern, with significant implications for the health and well-being of affected children[1]. Over the past four decades, the prevalence of childhood obesity has risen more than eightfold[2]. World Obesity Federation estimated that by 2030, 40 million children under the age of five and 254 million children aged 5–19 will be overweight or obese[3]. In Iran, the prevalence of obesity and overweight among children stand at 10.32% and 12.48%, respectively[4].

Food-insecurity, a lack of access to sufficient and nutritious food, can lead to a range of adverse health outcomes[5,6]. A systematic review and meta-analysis study revealed that 55.9% of the healthy Iranian population experiences food insecurity[7]. Children facing food-insecurity are at a higher risk of obesity due to limited access to healthy food options, often forcing them to rely on cheaper, less nutritious alternatives. This can result in diets high in calories but low in essential nutrients, contributing to unhealthy weight gain or obesity[5]. Although children aged 6–12 are in a critical growth phase, requiring energy intake proportional to their activity levels and growth spurts, the concern is not solely caloric content but the balance between calorie sources and nutritional

[1]Department of Community Nutrition, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran. [2]Nutrition Research Center, Shiraz University of Medical Sciences, Shiraz, Iran. [3]School of Food and Nutritional Sciences, University College Cork, Cork, Ireland. ✉email: kazemiasma66@gmail.com; s_kazemi@sums.ac.ir

quality[8]. This issue is particularly important for girls, as their growth spurts often begin earlier than those of boys, starting around ten and peaking at twelve. During this period, their nutritional needs significantly increase to support their growth and physical development[8].

Food-insecurity is a multifaceted issue influenced by various factors, including nutrition knowledge[9]. Recent studies have highlighted a significant relationship between an individual's understanding of nutrition and their food-security status[9,10]. A lack of nutrition literacy among children and their caregivers is a critical factor in the rising rates in childhood obesity[11]. Nutrition literacy refers to the obtaining, processing, and understanding of basic nutrition information necessary for making healthy food choices[12,13].

Mothers play a crucial role in shaping their children's dietary habits[14], as maternal nutrition literacy and behaviors significantly influence their children's food choices[15]. Mothers with a better understanding of healthy eating principles are more likely to promote healthier food choices within their household[14]. However, the impact of food literacy programs is different among different subgroups[16]. Food-insecure households may respond differently to food literacy programs[17], and a relationship between food-insecurity and food and nutrition literacy (FNL) has been indicated by observational studies[17–19].

Multiple studies in recent years have investigated the relationship between food-insecurity and obesity[20–22], as well as the association between FNL and obesity[23–25]. However, there is a gap in the literature regarding the relationship between FNL and obesity in different food-insecurity conditions. Particularly significant is the role of maternal FNL in influencing children's dietary choices, with a notable absence of research linking maternal FNL to childhood obesity within food-insecure households.

Thus, in the current study, we aimed to investigate the relationship between maternal FNL and childhood obesity in children living in food-insecure household compared to the those in food-secure households. The finding from this study will provide valuable insights into the potential benefits of nutrition education programs aimed at enhancing the health and well-being of children in food-insecure environments.

Methods

This cross-sectional study was conducted in autumn and winter 2023–2024 in Shiraz.

Study sample

The study participants were schoolchildren in the age range of 6–12 years, along with their mothers. We selected this age group due to the importance of childhood obesity, and accessing this age group is more facilitated than younger children by their attendance in schools. Moreover, ages 6–12 mark a critical period when children start school and establish their dietary habits[26]. Inclusion criteria for children were being enrolled in elementary school and willingness to participate, and for mothers, they were as follows: between the ages of 20 and 55 who do not have any particular medical illnesses, including cancer, long-chronic metabolic diseases, hepatic or renal disorders, thyroid abnormalities, cognitive problem, pregnancy, or breastfeeding. Research Ethics Committee of Shiraz University of Medical Sciences approved the study protocol (IR. SUMS.SCHEANUT. REC.1402.019), and all methods were performed in accordance with the guideline of the Declaration of Helsinki guideline. All mothers who participated in the study provided written informed consent for themselves and their children. The schools were divided into three socioeconomic categories: affluent, semi-affluent, and deprived. Three schools were randomly selected from each socioeconomic category, and thirty-five students were randomly selected from each school.

Sample size calculation

Power Analysis & Sample Size (PASS) software was used to calculate the sample size. A sample size of 330 was estimated considering the type 1 error of 5%, the power of 80%, the prevalence of 56% and 14% for food-insecurity and poor FNL, respectively[19], and to detect the relationship between them using logistic regression based on the adjusted odds ratio (OR) of 2.89, reported in Khorramrouz et al. study[19]. To consider a dropout of 20 participants, a final sample size of 350 was determined.

Measures

Sociodemographic and economic characteristics

Data related to sociodemographic and economic characteristics were collected through face-to-face interviews. This information included children's age and sex, parents' age, education, and occupation, household size, the condition of the residential property (e.g., number of rooms and ownership status such as property, rent, mortgage, or installment payments), access to living facilities (e.g., computer, laptop, car), household income, monthly food expenditure, and medication consumption.

Anthropometric measures

Anthropometric measures for mothers and children were performed as follows: weight was measured using a digital scale (Glamor BS-801 Hitachi China) with an accuracy of 100 g, with participants wearing minimal clothing and no shoes. Height was measured using a tape with a sensitivity of 0.1 cm, while the participants stood barefoot against a wall, with their shoulders, hips, and backs of the feet in contact with the wall.

Overweight and obesity in children were determined using BMI for age (BMI z-score) based on the World Health Organization (WHO) standards. According to the WHO definitions, overweight is classified as a BMI-Z-score between $> +1$ and $\leq +2$, while obesity is a Z-score $> +2$[27,28].

Food and nutrition literacy (FNL)

A 60-item Food and Nutrition Literacy Assessment Tool (FNLAT) was used to evaluate FNL of mothers by face-to-face interviews. This questionnaire was previously designed and validated for use in Iran[29]. It comprises

two domains (knowledge and skills) and six dimensions: advocacy (7 things), functional skills (11 items), food and nutrition knowledge (27 items), interactive skills (7 pieces), critical analysis of information (5 items), and food label reading competence (3tiems). The knowledge domain and food label reading skills are evaluated by 30 binary questions, while the other skill domains (excluding food label reading) are assessed through 30 Likert-type statements. The Table 1 lists the knowledge and skill area covered in the questionnaire. Overall FNL scores range from 0 to 100, with higher scores indicating greater food and nutrition literacy. Scores below 45 indicate poor literacy, scores above 60 represent adequate literacy, and scores between 45 and 60 are classified as moderate. The questionnaire is available as Supplementary File 1.

Food-insecurity

Household food-insecurity was assessed using the Household Food-insecurity Access Scale (HFIAS), a tool for assessing household food-insecurity in developing countries[30]. The HFIAS consists of nine items, which has been translated and validated for usage in the Iranian population[31]. Each item includes four response options reflecting the frequency of experiencing specific situation during the last month, rated as follows: 0 = never, 1 = rarely (once or twice), 2 = sometimes (3 to 10 times), and 3 = often (more than ten times). The questions are related to three different areas of food-insecurity (15): (1) concern and uncertainty about household food storage; (2) improper quality (including variety and food preferences); (3) receiving insufficient food and its physical complications. The HFIAS produces a score ranging from 0 to 27, which categorizes food insecurity into four levels: food-secure (0–1), mild (2–8), moderate (9–14), and severe (15–27) food-insecure conditions.

Statistical analysis

The baseline characteristics for continuous variables were summarized using mean (SD), while total count and percentage were used for categorical variables. The normality of quantitative variables was assessed through three methods[32]: (1) visual inspection with a histogram, (2) the Shapiro–Wilk test, and (3) measures of central dispersion. The association between the main exposures (independent variables)—mother's nutritional literacy (low literacy vs normal literacy) and family food security (severe or moderate insecurity vs security)—and the binary outcome (dependent variable) of childhood obesity (obesity vs normal) was explored using both logistic regression model and Structural Equation Modelling (SEM). Logistic regression was applied as a standard method for estimating associations between the exposures and the outcome[33], while controlling for potential confounders (mother's age, mother's education, family income, and child's sex). Potential confounders, explained later in this section, were selected to be included in the models based on previous literature and if they showed a univariable association with the study outcomes at a P-value < 0.2. The adjusted OR represents the odds of obesity among food-insecure children as compared to their food-secure counterparts, or between those with good versus poor maternal FNL, while controlling for confounding variables[34]. An odds ratio (OR) greater than or less than one for food insecurity indicates that the odds (probability/1- probability) of risk of childhood obesity are higher or lower, respectively, in children experiencing food insecurity compared to those with food security. The 95% confidence intervals (CI) indicate the precision of the estimates with 95% certainty[35]. As this study has a cross-sectional design, the findings reflect prevalence rather than risk. However, since prevalence is a function of both risk and duration, and assuming the duration of obesity does not differ substantially between children with and without food insecurity due to its stable nature and non-fatal characteristics, the prevalence ratio can be considered a reasonable approximation of the risk ratio and so is its odds ratio[36]. A similar interpretation applies to the OR for maternal nutritional literacy.

The use of SEM complemented logistic regression by allowing us to simultaneously model the relationships among multiple variables, including direct and indirect pathways. SEM provides a framework to account for complex interrelationships, such as potential mediation or covariation between exposures (e.g., the interplay between maternal nutritional literacy and family food security) and offers insights into the underlying structural relationships within the data. We evaluated our SEM models by comparing those with and without the inclusion of maternal education and income variables, using likelihood ratio tests (LRT), Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC). To examine multicollinearity, we analyzed the correlation matrix. The goodness-of-fit of the model was assessed using a receiver operating characteristic (ROC) curve.

We assessed the sensitivity of the observed associations to the hypothesized conceptual model by using SEM, ensuring the robustness of our findings. Both SEM and logistic methods yielded consistent results, supporting

Domains	Dimensions	Sub-dimensions
Knowledge	Food and nutrition knowledge	Knowledge of nutrition basic Knowledge of shopping, storage and preparation of foods Knowledge of food production and environmental sustainability Cultural and social issues related to food
Skills	Functional skills	Applying basic food and nutrition knowledge Shopping and storage of foods and meal preparation skills Food production and environmental sustainability related skills
	Interactive skills	Seeking food and nutrition information Interact with others (family, friends, practitioners, etc.) about food and nutrition
	Critical skills	Analysis of food and nutrition information critically Advocacy for promoting healthy and sustainable food choice

Table 1. Identified domains, dimensions and sub-dimensions of Food and Nutrition Literacy.

the validity of our conclusions. SEM added value by allowing us to explore and confirm the hypothesized structural relationships among variables while accounting for the complexity of interdependencies in the data.

Food security was analyzed either as a binary variable or three-level categorical variable (secure, mild insecurity, and moderate/severe insecurity). Due to the small number of participants with severe food-insecurity, the moderate and severe categories were combined. Maternal FNL was treated as a binary variable. To explore the joint effects of food security and maternal FNL, children were classified into four groups: (1) food insecure/poor FNL, (2) food secure/poor FNL, (3) food insecure/good FNL, and (4) food secure/good FNL. For dose–response analyses, we test for linear trend across the three categories of food-insecurity. To calculate the p value for trends, we assigned the median values for each category. To assess the potential interaction of food-insecurity and maternal FNL in relation to childhood obesity, the likelihood ratio test was used. As mentioned above, all models were adjusted for maternal age and education (diploma or less vs. university graduation), children's age and sex, and household income. Income was originally measured as a four-category variable. However, due to relatively small sample sizes in the first and last categories, it was recategorized into a binary variable with of > 10 and ≤ 10 categories to avoid a potential sparse data problem. All statistical analyses were conducted using Stata 18.5.

Results

A total of 350 participants were enrolled to participate in the study. Out of these, 23 were excluded for not meeting the inclusion/exclusion criteria, resulting in a final sample of 327 mothers. The characteristics of the participants, characterized by food-security and FNL levels, are detailed in Table 2.

The mean (SD) ages of mothers and their children were 38.08 (5.08) years and 9.0 (1.72) years, respectively. The majority of mothers were housewives (81.60%), and had education levels below university (64.12%).

Among the participants, 159 (48.62%) were classified as food-secure, while 133 (60.67%), 28 (8.56%), and 7 (2.14%) experienced mild, moderate, and severe food-insecurity, respectively. Notable, 55% of children were female, and 34.46% were classified as overweight or obese. The mean score of FNL was significantly higher in the food-secure group (66.4 ± 11.8) compared to the food-insecure group (56.5 ± 13.6). Statistically significant differences were observed between the food-security and FNL groups in terms of maternal age and BMI, children's BMI and BMI for age (BMI z-score), parental education and occupations, household size, and home ownership.

Food-insecurity and children overweight/obesity

Analysis the relationship between household food-insecurity and children's overweight/obesity showed that while moderate/severe food-insecurity was associated with an increased risk of obesity, the risk associated with

Variables	Total (n = 327)	Food secure (n = 159)	Food insecure (n = 168)	P value	Poor FNL (n = 187)	Good FNL (n = 140)	P value
Mother Age, y	38.1 ± 5.1	37.2 ± 4.6	38.8 ± 5.3	0.003	37 ± 5	39 ± 5	< 0.001
Mother BMI, kg/m^2	26.7 ± 5.5	24.9 ± 4.5	28.1 ± 5.8	< 0.001	30.13 ± 5.23	24.13 ± 4.12	< 0.001
Child Age, y	9.0 ± 1.8	8.9 ± 1.7	9.0 ± 1.8	0.63	9 ± 2	9 ± 2	0.63
Child BMI, kg/m^2	18.0 ± 4.0	17.5 ± 3.3	18.4 ± 4.4	0.060	17.03 ± 3.4	19.33 ± 4.4	< 0.001
Child BMI-ZSCORE	0.41 ± 1.8	0.2 ± 1.5	0.5 ± 1.8	0.25	0.08 ± 1.6	0.84 ± 1.9	< 0.001
FNLAT-SCORE	61.4 ± 13.7	66.4 ± 11.8	56.5 ± 13.6	< 0.001	71.13 ± 7.3	48.33 ± 8.4	< 0.001
HFIAS-SCORE	2.8 ± 3.9	0.1 ± 0.3	5.2 ± 4.2	< 0.001	2 ± 3	4 ± 5	< 0.001
Food insecurity status, n (%)							
Secure	159 (48.2)	–	–		42 (30.0)	117 (62.57)	< 0.001
Mild	133 (40.67)	–	–		67 (47.86)	66 (35.29)	
Moderate	28 (8.56)	–	–		26 (18.57)	2 (1.07)	
Severe	7 (2.14)	–	–		5 (3.57)	2 (1.07)	
Child Sex, n (%)							
Girl	180 (55.0)	92 (57.9)	88 (52.4)	0.32	106 (56.7)	74 (52.9)	0.49
Mother education, n (%)							
School	209 (64.11)	70 (44.3)	139 (82.7)	< 0.001	116 (82.9)	93 (50.0)	< 0.001
University	117 (35.89)	88 (55.7)	29 (17.3)		24 (17.1)	93 (50.0)	
Mother job, n (%)							
Non-employed	256 (81.60)	149 (88.7)	117 (74.1)	< 0.001	141 (75.8)	125 (89.3)	0.002
Employed	60 18.40	19 (11.3)	41 (25.9)		45 (24.2)	15 (10.7)	

Table 2. Characteristics of mothers, children, and households according to food security and food and nutrition literacy subgroups. Categories were reported as number or percentage of subjects. Continuous variables were reported by means and standard deviation. Independent t test was used for quantitative variables and χ^2 test for qualitative variables. *BMI* body mass index, *FNL* food & nutrition literacy, *FNLAT* Food and Nutrition Literacy Assessment Tool, *HFIAS* Household Food Insecurity Access Scale

Security categories	OR (95%CI), crude	OR (95%CI), adjusted*	P dose–response
Mild insecure vs. secure	1.41 (0.83, 2.39)	1.42 (0.77, 2.65)	0.007
Moderate/severe insecure vs. secure	5.20 (2.36, 11.46)	4.64(1.75, 12.29)	
Insecure (Mild, moderate, severe) vs. secure	1.91 (1.17, 3.11)	1.63(0.90, 2.98)	–

Table 3. The relationship between household food insecurity and childhood overweight/obesity. *Adjusted for age (mothers and children), children gender, mothers' education, and income.

Subgroups	OR (95% CI), crude	OR (95% CI), adjusted*
Total	0.29 (0.17, 0.48)	0.29 (0.17, 0.51)
Food secure	0.31 (0.14, 0.70)	0.26 (0.11, 0.65)
Food insecure	0.33 (0.16, 0.66)	0.37 (0.17, 0.79)

Table 4. Relationships between maternal food and nutrition literacy and children overweight/obesity among food-secure and -insecure households. *Adjusted for age (mothers and children), children gender, mothers' education, and income.

Groups	OR (95% CI), crude	OR (95% CI), adjusted
Food insecure/poor FNL	1.0	1.0
Food secure/poor FNL	0.79 (0.36–1.72)	1.0 (0.41, 2.38)
Food insecure/good FNL	0.33 (0.16–0.66)	0.36 (0.17–0.74)
Food secure/good FNL	0.25 (0.13–0.46)	0.24 (0.11–0.53)

Table 5. Odds of childhood overweight/obesity among the subgroups of combination of food security and nutrition literacy status. *Adjusted for age (mothers and children), children gender, mothers' education, and income.

mild food-insecurity was not statistically significant (Table 3). Moreover, a significant trend was observed toward increase in childhood obesity with the worsening of food insecurity (P dose–response = 0.007).

Maternal FNL and children overweight/obesity

Our findings indicate a significant association between maternal FNL and a reduced risk of overweight/obesity in children with an OR of 0.29 and a 95% CI of 0.17–0.51 (Table 4).

Interaction between maternal FNL and food-insecurity

The results indicated that even in food-insecure households, good maternal FNL was associated with a significant reduction in the risk of childhood overweight/obesity risk compared to poor FNL (OR 0.37, 95% CI 0.17–0.79). However, no interaction between food-security and FNL was identified (P = 0.39) (Table 4).

To further explore the relationship between maternal FNL, food-insecurity, and children's overweight/obesity, we conducted a subgroup analysis by combinations of food-security and maternal FNL status. The odds of childhood overweight/obesity in food-insecure with good FNL was significantly lower compared to those from food-insecure household with poor FNL. Conversely, the odds for children in food-secure household with poor FNL was not significantly different from those in food-insecure household with poor FNL (Table 5).

The association between the maternal FNL, food-insecurity and childhood obesity was also explored using SEM. In the SEM analysis, we stratified the models by children's sex, as we could not assume causal relationships (arrows) from children's sex to either maternal nutritional literacy or family food security. This stratification indicated that the structural relationships didn't differ between girls and boys, so the pooled results were reported. The SEM diagram illustrating assumed relationships is shown in Fig. 1. The results are presented as OR and 95% confidence intervals (CI) in Table 6. The model incorporating maternal education and income demonstrated superior performance, with AIC and BIC values of 1126.4 and 1186.6, respectively, and a statistically significant LRT p-value (< 0.001). Furthermore, this model outperformed the corresponding model with continuous BMI when assessed using AIC and BIC metrics. The highest observed correlation in the correlation matrix was 0.39 between income and education. This suggests no significant multicollinearity issue. The AUC of model was 67.2% (95% CI: 60.6% to 73.8%). This AUC indicates a moderate level of discriminative ability, suggesting that while the model can differentiate between outcomes better than chance, there remains room for improvement in predictive performance.

Discussion

The present study investigated the relationship between maternal FNL and the risk of and childhood obesity in varying food-security contexts. The results indicated that moderate/severe food-insecurity was associated with

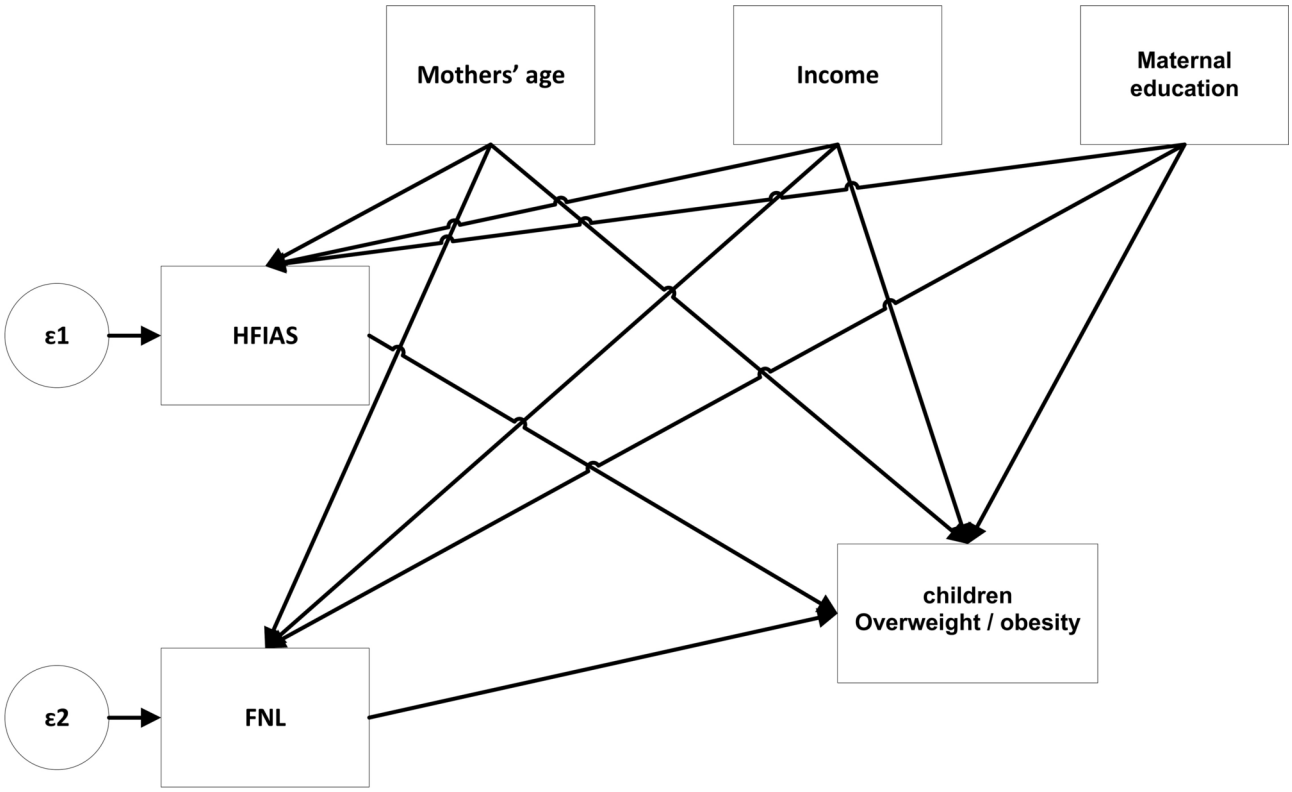

Fig. 1. Structural equation modeling diagram illustrating assumed relationships between mediating variables have a role in relationship between maternal food and nutrition literacy, household food-insecurity access scale and childhood obesity.

Variables	OR	SE	z	P value	95% CI
HFIAS	1.14	0.36	0.41	0.684	0.61, 2.13
FNL	2.9	0.83	3.72	0.000	1.66, 5.08
Mother age	1.03	0.03	1.01	0.311	0.97, 1.08
Income	0.76	0.23	− 0.92	0.356	0.42, 1.37
Mother education	1.02	0.24	0.08	0.940	0.64, 1.62
Constant	0.12	0.14	− 1.76	0.078	0.01, 1.27

Table 6. The relationships between multiple variables and childhood obesity. *FNL* food & nutrition literacy, *HFIAS* Household Food Insecurity Access Scale, *OR* odds ratio, *CI* confidence interval

the increased odds of overweight or obesity in children. Moreover, maternal FNL was associated with a reduced odd of childhood overweight/obesity, both in food-secure and insecure households. In other words, mothers with good FNL were less likely to have overweight/obese children, even in food-insecure conditions. Conversely, mothers with poor FNL, even in food-secure households, did not see a reduction in the risk of overweight or obesity in their children.

The relationship between food-insecurity, FNL, and obesity may be mediated through several mechanisms. Food insecurity often leads individuals to prioritize caloric intake over nutritional quality due to financial constraints. Consequently, they may consume more processed foods that are high in sugars and fats but low in essential nutrients which contributing to obesity[19,37,38]. Conversely, while food-secure households generally have better access to a variety of food options, they may also face challenges related to an overreliance on processed foods. The convenience and marketing of these products can lead to unhealthy dietary patterns, including higher consumption of fast foods and snacks that are often more accessible than fresh produce[39]. This dynamic highlights a dual challenge: food-insecure households struggle with affordability and limited access to nutritious options, while food-secure households may inadvertently compromise dietary quality through convenience-driven choices. Moreover, low FNL further complicates these issues. In both contexts—food-insecure and food-secure—individuals with limited nutrition literacy may lack the skills necessary to make informed dietary choices. For instance, without the ability to read food labels or understand portion sizes, families may opt for processed foods that appear convenient but are nutritionally inadequate. This lack of knowledge can perpetuate

poor dietary habits and contribute to obesity, even when healthier options are available[23,40]. Thus, mothers' nutritional literacy plays a significant role in guiding family dietary choices. Additionally, factors such as socioeconomic status, education level, and access to resources significantly influence both food security and nutrition literacy. Communities with high levels of food insecurity often lack access to educational programs that promote nutrition literacy[41].

Previous studies have not investigated the relationship between FNL and obesity in different food-insecurity conditions. Some studies have investigated the relationship between food-insecurity and obesity[20–22], and some investigated the association between FNL and obesity[23–25]. We will discuss about these studies in the following. Our study addresses the gap in previous studies by indicating maternal FNL as a protective factor against childhood obesity, even in food-insecure households. Our findings suggest that enhancing mothers' nutritional knowledge can help alleviate some of the negative effects associated with food insecurity.

The studies that have investigated the relationship between nutrition literacy and obesity have mainly focused on adolescents rather than on younger children. The findings from these studies present a mixed picture, revealing both significant associations and notable discrepancies. A cross-sectional study involving 18,176 adolescents in China found an inverse association between nutrition literacy and overweight/obesity, particularly among senior high school students but not among those in junior high school[24]. In contrast, a cross-sectional study of 1,074 secondary school students in Turkey reported no significant difference in BMI and anthropometric measurements according to adolescents' nutrition literacy level[42]. Furthermore, another cross-sectional study of 189 adolescents aged 14–19 years in Lebanon found no association between different aspects of nutrition literacy and BMI or food habits[43]. Some themes or lessons can be drawn from these studies; the effect of mothers' nutritional knowledge on children's dietary intake and obesity may differ from the effect of children's own nutritional knowledge on their dietary intake and obesity. It is possible that a child, despite lacking good nutritional knowledge, may makes healthy food choices and maintain a normal weight because their mother has good nutritional knowledge. On the other hand, a child or an adolescent, despite having good nutritional knowledge, may has unhealthy food choices because of the peer influence.

Our findings indicate an inverse association between maternal FNL and childhood overweight/obesity. Notably, our study differs from these studies in two key aspects: the age of the population and the assessment of FNL among mothers, whereas these studies assessed FNL among adolescents. Moreover, none of the previous studies investigated the relationship between FNL and obesity with respect to the food-insecurity. Therefore, our study fills a critical gap by examining younger children, a key demographic during which dietary habits are formed[26]. Furthermore, it contributes to the existing research by showing that maternal FNL can help to alleviate the negative effects of food-insecurity on childhood overweight/obesity. This suggests that nutrition education programs targeting mothers, particularly those in food-insecure households, could be an effective strategy to reduce the risk of childhood overweight/obesity.

Many studies have investigated the relationship between food-insecurity and childhood obesity. We will focus on the key reviews of original studies. A systematic reviews and meta-analysis of 32 (25 cross-sectional and 7 cohort designs) studies in under 18 years individuals revealed that children and adolescents in food-insecure condition are not at risk of overweight/obesity, totally. However, food insecurity was linked to an increased risk of overweight/obesity among certain subgroups, particularly children and adolescents living in developed countries or facing severe food-insecurity.

Another systematic review and meta-analysis, which included both children and adults from high-income countries, found statistically significant associations between food insecurity and obesity. The design of included studies except one was cross-sectional.

Additionally, a separate systematic review examined 18 longitudinal studies on US children aged 1–19 years, assessing outcomes such as obesity, BMI, and BMI z-score. Half of these studies found no significant association; one study identified a negative association, while the remainder reported positive associations. Notable, some studies found positive associations within certain subgroups defined by sex and age, among girls and older children.

A review of 16 studies on overweight and obesity among children aged 0–5 years in developed countries showed mixed results: seven studies did not find a significant association, three reported a positive association, and one found a negative association. Furthermore, five studies indicated that results varied by sex, with positive associations observed among the girls and children of Mexico and Pakistan descent, but not among White British children.

The criteria for defining overweight and obesity in studies included in these reviews typically used the ≥ 85th and ≥ 95th percentile. However, food-insecurity was assessed by different questionnaires, which could introduce potential bias. These reviews suggest that several factors influence the relationship between food insecurity and childhood obesity, including the severity of food-insecurity, differences between high- and low-income countries, and variations related to age and sex[21,44]. For instance, food-insecurity is associated with a higher likelihood of overweight and obesity in children and adolescents from high-income countries, whereas such an association is less clear in low-income countries[44]. Moreover, severe food-insecurity is specifically correlated with an increased risk of overweight and obesity, while mild or moderate food-insecurity does not show a significant relationship with these conditions[44,45]. Additionally, food-insecurity appears to be more strongly associated with BMI z-scores in younger children, while studies investigated older children show weaker associations[6,46–48]. Some studies report that food-insecurity is associated to higher BMI z-scores in girls[6,46–48], while others reported higher BMI z-scores for boys[47]. Consistent with previous studies, our findings emphasize the importance of the severity of food insecurity, revealing a positive relationship between moderate and severe, but not mild, food insecurity subgroups. Nonetheless, our study suggests that maternal FNL can help diminish this risk; mothers with good nutrition literacy are more efficient to make informed decisions about their children's diet,

regardless of the availability of food. This highlights the need for targeted nutrition education programs focused on improving mothers' nutrition knowledge, particularly in food-insecure households.

We didn't find a significant interaction between food-security and FNL. This insignificance could stem from several factors; for instance, a small sample size may limit the power to detect interactions. Since exploring the interaction was not our primary objective, it is likely that our sample size was insufficient to provide enough statistical power. Additionally, the complexities or unmeasured variables in the relationship within the relationship between maternal nutrition literacy, food insecurity, and childhood obesity, as previously discussed, may also play a role. Lastly, the absence of a significant interaction suggests that the impact of maternal nutrition literacy on childhood obesity is consistent across different levels of food insecurity. This implies that enhancing maternal nutrition literacy is likely beneficial for all mothers, regardless of their food security status.

Implication of the findings

Our findings have important implications for public health policy and practice, suggesting that nutrition education programs oriented towards mothers could effectively reduce the risk of childhood overweight/obesity. Such programs should incorporate hands-on workshops that allow mothers to practice their skills in a supportive environment, and integrate behavioral change theories to help mothers apply their nutrition knowledge effectively. Ongoing evaluation of these programs is essential to ensure they remain relevant and impactful.

Suggestions for future studies

In our study we uncovered several important findings, yet numerous unresolved questions remain. One key area for further exploration is the mechanisms through which maternal FNL influences children's obesity status. While we found a significant association between higher maternal FNL and reduced odds of childhood obesity, particularly in food-insecure households, understanding the specific pathways—such as dietary choices, food preparation practices, or health-related behaviors—would provide deeper insights into this relationship.

Other unresolved questions pertain to the role of children's preferences in shaping dietary habits within families and the impact of peer influence on children's eating behaviors. To explore these issues in future studies, using longitudinal designs to track changes in children's preferences and parental choices over time may be helpful. This would help identify causal relationships and the long-term effects of peer influence and parental responses. Measuring children's social networks and dietary habits among friends to could also be helpful to assess the impact of peer influence. Additionally, exploring genetic predisposition and assessing the children physical activity will provide a more comprehensive view of the factors affecting the relationship between childhood obesity, food-insecurity, and maternal FNL.

Strength and limitation

Our study has several limitations. First, the cross-sectional nature of the study limits the ability to establish a causal relationship between the variables. Longitudinal studies are required to better understand the long-term effects of maternal FNL and food-insecurity on childhood obesity. Second, our study relied on self-reported data for household food-insecurity. This method is susceptible to various biases that may affect the validity and reliability of the data, including response bias (participants providing inaccurate answers to appear favorable)[49], recall bias (misremembering past events)[49], exaggeration or minimization bias (individuals might exaggerate issues for sympathy or downplaying problems to avoid stigma)[50], contextual influences (the emotional state of respondents during data collection)[49], and reference bias (individuals may have different standards for evaluating their behaviors)[51]. Additionally, other potential factors, such as genetic predisposition to obesity and children's physical activity levels, were not examined in this study. This omission may have led to an overestimation of the relationship between food insecurity, nutrition knowledge, and obesity risks, as genetic factors and physical activity influences were not accounted for. Due to the extensive nature of the questionnaires and the likelihood of decreased participant cooperation, we were unable to assess physical activity levels.

Other unmeasured variables in our study are peer influence and the children's influence on parental choices. Peer influence plays a vital role in shaping children's dietary habits from a very young age, and becomes even more pronounced as children grow into adolescence[52]. Studies have shown that adolescents often imitate unhealthy eating patterns observed in their peer groups, leading to increased consumption of energy-dense and low-nutrition foods[53]. Therefore, peer effect is an unmeasured variable that may also influenced our results and may led to underrepresenting of the complexity of children's dietary behaviors. For example, if children are heavily influenced by their peers to choose unhealthy foods, this could overshadow the potential benefits of maternal nutrition education. Regarding the children's influence on parental choices, children's food preferences can significantly impact parental decision-making regarding meal planning and grocery shopping. Parents often feel compelled to accommodate their children's likes and dislikes, which can inadvertently lead to less healthy food choices[54]. This issue also contributes to presenting the relationship as weaker.

Conclusion

In conclusion, our study indicated a significant relationship between moderate/severe food-insecurity and overweight or obesity in children. Moreover, maternal FNL was associated with a reduced risk of overweight/obesity in children, even in food-insecure conditions.

Data availability

The data that support the findings of this study are available from the authors but restrictions apply to the availability of these data by Shiraz University of Medical Sciences, and so are not publicly available. Data are, however, available from the corresponding author upon reasonable request.

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Author contributions
AK and MH designed the study. MH and KN carried the study (excutive phase). HHM performed the statistical analysis. AK wrote the manucript. MA criticaly revised the manuscript.

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Declarations

Competing interests
The authors declare no competing interests.

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Correspondence and requests for materials should be addressed to A.K.