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Short Communication

Evaluating socio-demographic, behavioral, and maternal factors in the dual burden of malnutrition among school-aged children in Batam, Indonesia

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Abstract

Malnutrition among school-aged children in urban-industrial settings presents a dual burden of undernutrition and overnutrition. The aim of this study was to examine factors influencing the nutritional status of elementary school children in Batam, Indonesia. A case-control study was conducted in Batam, focusing on children aged 6–12 years, with malnourished cases (undernutrition and overnutrition) and well-nourished controls, along with their mothers. Respondents were selected through stratified random sampling from public elementary schools. Inclusion criteria encompassed children enrolled in these schools, while exclusion criteria involved children with chronic health conditions. Data were collected via structured interviews utilizing validated questionnaires, anthropometric assessments (weight-for-age and height-for-age), and parent-reported socioeconomic, behavioral and family characteristics. Statistical analysis involved binary logistic regression to identify significant risk factors associated with malnutrition. A total of 188 children, including 94 malnourished cases (40 undernutrition and 54 overnutrition) and 94 well-nourished controls. The findings revealed significant differences between cases and controls in socioeconomic factors (pocket money (p=0.027), family income (p=0.042)), behavioral factors (sedentary activity (p=0.019), dietary habits (p=0.037)) and family factors (maternal BMI, p=0.011; maternal nutritional knowledge, p=0.004; parenting style, p=0.035). Dominant risk factors for malnutrition (undernutrition or overnutrition) included poor dietary habits (adjusted odds ratio (aOR): 0.451; 95%CI: 0.225–0.901; p=0.024), maternal obesity class II (aOR: 0.126; 95%CI: 0.030–0.535; p=0.005), and low maternal nutritional knowledge (aOR: 0.294; 95%CI: 0.124–0.696; p=0.005). Targeted family-centered interventions focusing on dietary practices and maternal education are therefore recommended to address this issue.

Keywords: Dual burden, malnutrition, urban-industrial setting, dietary habit, maternal knowledge

Introduction

Malnutrition remains a critical global health issue, particularly in developing countries, where it affects school-aged children in urban-industrial contexts [1]. According to the World Health

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Organization (WHO), 1.8 billion children worldwide are aged between 5 and 15 years, with 90% residing in low- and middle-income countries [2]. Malnutrition manifests in multiple forms, including undernutrition (wasting, stunting, underweight), micronutrient deficiencies, and overnutrition (overweight, obesity, diet-related non-communicable diseases) [3]. WHO data reveals that 390 million children aged 5–19 years suffer from overnutrition, while 190 million face undernutrition, highlighting significant disparities in child nutrition despite global efforts to address these concerns [2].

In Indonesia, the burden of malnutrition among school-aged children is multifaceted, encompassing undernutrition, micronutrient deficiencies, and overnutrition. The 2023 Indonesian Health Survey reports that 3.5% of children aged 5–12 years are severely underweight, 7.5% are underweight, 11.9% are overweight, and 7.8% are obese [4]. These data reflect the complex nutritional challenges in the country, exacerbated by urbanization, especially in industrial areas like Batam. Rapid industrialization and urbanization in such areas alter local food environments, increasing access to processed, low-nutrient foods [5]. Furthermore, the COVID-19 pandemic has disrupted food security and exacerbated nutritional issues, contributing to a growing concern about the "dual burden" of malnutrition (undernutrition and overnutrition) [6]. In Batam, 23.57% of school-aged children are overnourished, with 9.82% overweight and 10.53% obese, revealing a pressing need to understand the influence of urban-industrial settings on child nutrition [4].

Childhood nutritional status is influenced by various factors, including dietary intake, metabolic needs, and socioeconomic determinants such as age, sex, physical activity, household income, parental weight, knowledge, and dietary habits [7-9]. The period of school-age development is critical, as poor nutrition at this stage is linked to long-term health issues in adulthood, such as cardiovascular diseases and diabetes [10]. Urban-industrial environments, characterized by sedentary lifestyles and increased availability of unhealthy food options, exacerbate malnutrition. Studies have shown that urban populations tend to have higher body mass indexes (BMI) compared to rural populations, suggesting the significant impact of environmental factors on child nutrition [11-13]. Additionally, factors like parental occupation, environmental hygiene, and social support from teachers and peers also significantly influence nutritional outcomes, highlighting the importance of addressing social determinants of health in public health strategies [14-16].

The consequences of malnutrition extend beyond physical health, adversely affecting education and economic opportunities [1]. Malnourished children often face weakened immune systems, stunted growth, and cognitive impairments, which can lead to reduced learning capacity and academic performance [17,18]. Similarly, children affected by overnutrition face disruptions in school attendance and academic success [19]. Given the dual burden of malnutrition, addressing these issues in school-aged children is vital for improving their health and educational outcomes. The aim of this study was to examine how socioeconomic, behavioral, and family factors influence the nutritional status of elementary school children in Batam, Indonesia, using the Social Determinants of Health Theory [20] to explore how local socioeconomic factors shape nutritional outcomes. By focusing on these determinants, this study is expected to provide evidence to inform public health interventions, tailored nutritional programs, and future research on child health in urban-industrial environments.

Methods

Study design and setting

A case-control study was conducted in Batam, Indonesia, over three months, from November 2023 to January 2024, to evaluate the socioeconomic, behavioral, and maternal factors influencing the dual burden of malnutrition (undernutrition and overnutrition) among school-aged children. The study targeted children enrolled in elementary schools across Batam. Cases were defined as children experiencing malnutrition, classified into two subgroups based on the WHO anthropometric standards: undernutrition (severely underweight and underweight) and overnutrition (overweight and obese). Controls comprised children with normal nutritional

status, matched to cases by age and sex. The number of participants in the case and control groups was equal to ensure statistical comparability.

Sampling strategy

A stratified random sampling technique was employed to ensure representation across nutritional categories. Sampling was performed proportionally across schools to account for potential socio-demographic variation. This design enabled the systematic investigation of associations between nutritional outcomes and key determinants, including socioeconomic status, behavioral factors, and family-related characteristics.

Respondents

The study included school-aged children and their mothers. Respondents were enrolled in elementary schools in Batam and resided with their parents or legal guardians. Children were selected based on their nutritional status, categorized into undernutrition, overnutrition, and normal nutritional status according to the Indonesian Ministry of Health growth standards [21]. These classifications were determined using BMI-for-age z-scores, where undernutrition was defined as a BMI-for-age below -2 standard deviations (SD), overnutrition as a BMI-for-age above +1 SD, and normal nutritional status as a BMI-for-age between -2 SD and +1 SD. Controls comprised children with normal nutritional status, while the case group consisted of undernutrition (severely underweight and underweight) and overnutrition (overweight and obese). Each child in the case group was matched by age and sex with a child in the control group from the same school classes. To ensure comprehensive data collection and account for familial influences, the mothers of all selected children were also included in the study.

The inclusion criteria for this study were as follows: school-aged children (6–12 years) who were enrolled in elementary schools in Batam and resided with their biological parents or legal guardians. Children who were diagnosed with chronic illnesses or congenital conditions that affected growth or nutritional status (e.g., diabetes, congenital heart disease, cerebral palsy), children or mothers who had significant communication barriers (e.g., severe language difficulties, hearing impairments), or cognitive impairments that could interfere with data collection, as well as children with recent acute illnesses or medical interventions that could temporarily alter nutritional status, were excluded from the study.

Data collection

Data collection employed structured questionnaires and anthropometric measurements to ensure a comprehensive and standardized methodology for both children and their mothers. For children, structured questionnaires were employed to gather information on pocket money allocation and sedentary behavior. Children's pocket money was recorded by asking about the average daily amount they received for school-related expenses. The classification was based on the sample distribution, where the mean and SD were used as cut-off points. Pocket money was categorized as low ($X < \text{mean} - 1SD$), moderate ($\text{mean} - 1SD < X < \text{mean} + 1SD$), and high ($X > \text{mean} + 1SD$).

Sedentary behavior was measured by assessing the time spent on activities such as playing video games, using mobile phones, watching TV, reading, and napping. These activities were selected due to their association with lower physical activity levels. The classification of sedentary behavior was determined based on the group mean. Children with scores below the mean were classified as having low sedentary behavior, while those with scores equal to or above the mean were categorized as having high sedentary behavior. These categorizations ensured a standardized approach to data analysis. Nutritional status was determined through anthropometric assessments, including weight and height measurements, conducted using calibrated instruments and standardized procedures.

For mothers, structured questionnaires were administered to evaluate maternal knowledge of nutrition, dietary habits, family income, and parenting styles. Family income was self-reported and categorized into predefined income brackets, which were based on National Socioeconomic Classification criteria. The income was categorized into three groups: less than IDR 2 million (low), IDR 2–3.9 million (moderate), and equal to or above IDR 4 million (high).

Parenting style was assessed using a validated instrument, classifying responses into authoritative, authoritarian, or permissive categories. Maternal BMI was determined through standardized anthropometric procedures, with height measured using a stadiometer and weight recorded with a digital scale. BMI was computed following WHO guidelines and categorized as follows: underweight (<18.5), normal (18.5–22.9), overweight (23.0–24.9), obesity I (25.0–29.9), and obesity II (≥30.0) [22]. All data were systematically recorded and managed according to standardized protocols to ensure consistency, reliability, and validity in the assessment of nutritional and behavioral factors in both children and their mothers.

Instruments

The semi-quantitative food frequency questionnaire (SQ-FFQ), a validated tool developed by the Indonesian Ministry of Health, was used to assess dietary intake [23]. This instrument consists of 83 food items categorized into six main groups: staple foods (e.g., rice, corn, potato, bread, cassava), animal-based side dishes (e.g., beef, fish, chicken, eggs, squid, crabs), plant-based side dishes (e.g., soybean, petai, tofu, tempeh), vegetables (e.g., radish, carrot, cucumber, mustard greens, eggplant), fruits (e.g., avocado, apple, melon, banana), and processed foods (e.g., meatballs, sausages, instant noodles). These categories were designed to capture dietary diversity and align with common dietary patterns in the Indonesian population. Food consumption frequency was quantified using a standardized scoring system: never (0), 2/month (5), 1–2/week (10), 3–6/week (15), 1/day (21), and >3/day (50). The total dietary intake score was obtained by summing individual scores across all food items, yielding a minimum possible score of 0 (no consumption of any item) and a maximum of 4150 (consumption of all items more than three times daily). Dietary patterns were classified based on the total score, with participants categorized as having a "good dietary pattern" if their score was equal to or above the group mean and "poor dietary pattern" if below. This standardized scoring approach ensured consistency in evaluating dietary habits and their potential associations with nutritional outcomes.

Maternal nutritional knowledge was measured using a 16-item questionnaire developed by the authors, covering three domains: food grouping (7 items), food processing (5 items), and balanced nutrition (4 items). Responses were scored on a dichotomous scale: correct (1 point) and incorrect (0 points). The total score categorized participants into three knowledge levels: "good" (13–16), "adequate" (9–12), and "poor" (0–8).

To ensure the validity and reliability of the maternal nutritional knowledge questionnaire, a pilot study was conducted with 30 respondents. Validity was assessed using the corrected item-total correlation (CITC) method, where items with CITC values below 0.374 were excluded. Following this refinement, four items were removed, resulting in a final 16-item questionnaire with CITC values ranging from 0.387 to 0.914. Internal consistency was evaluated using Cronbach's alpha, yielding coefficients of 0.846 for food grouping, 0.757 for food processing, and 0.914 for balanced nutrition, all exceeding the acceptable threshold of 0.60. This validated and reliable tool ensured accurate measurement of maternal nutritional knowledge in this study.

Parenting style was assessed using the parenting styles and dimensions questionnaire-short version (PSDQ-SF) [24], a 32-item instrument measuring three parenting dimensions: authoritative, authoritarian, and permissive. Responses were recorded on a 5-point Likert scale (1=never, 5=always), and mean scores were computed for each dimension. The Indonesian adaptation of this instrument demonstrated strong construct validity, with factor loadings ranging from 0.51 to 0.99. Reliability analysis confirmed satisfactory internal consistency, with Cronbach's alpha values of 0.86 for authoritative, 0.76 for authoritarian, and 0.67 for permissive parenting styles [25]. These psychometric properties ensured the appropriateness of the PSDQ-SF for assessing parenting styles in this study.

Statistical analysis

Data were analyzed using computerized statistical software. Descriptive statistics, including frequencies and percentages, were used in univariate analysis to summarize the distribution and characteristics of the study variables. For bivariate analysis, chi-square tests were employed to examine the association between each independent variable (pocket money, family income, sedentary activity, dietary habits, maternal BMI, maternal knowledge, and parenting style) and the dependent variable (nutritional status). A significance level of $p<0.05$ was used to identify

statistically significant associations. To ensure that potentially relevant predictors were not excluded prematurely, variables with *p*-values less than 0.25 from the bivariate analysis were included in the multivariate analysis.

Multivariate analysis was performed using a binary logistic regression model to identify factors associated with nutritional status while adjusting for potential confounders. This method suits dichotomous outcomes, such as the nutritional status categories (case vs control). Variables were selected based on their *p*-values in the bivariate analysis, and the model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test to ensure that the model adequately represented the data. Multicollinearity was checked by calculating variance inflation factors (VIFs) to confirm that no significant multicollinearity was present among the independent variables. The results were reported as adjusted odds ratios (aORs) with 95% confidence intervals (CIs).

Results

Socioeconomic, behavioral, and family characteristics of the study respondents

A descriptive summary of the socioeconomic, behavioral, and family characteristics of the study participants, stratified into case and control groups is presented in **Table 1**. The study enrolled school-aged children and their mothers, with the case group comprising children diagnosed with undernutrition (n=40) and overnutrition (n=54), all residing with their parents. The control group included children with normal nutritional status (n=94), individually matched by age and sex within the same school classes as the case group. Overall, 188 children participated in the study, evenly distributed between the case (n=94) and control (n=94) groups. Correspondingly, the mothers of all enrolled children were included, resulting in 94 mother-child pairs per group (**Table 1**).

In terms of socioeconomic factors, a majority of participants in both groups belonged to families in the very high-income category, accounting for 85.1% in the case group and 89.4% in the control group (**Table 1**). Regarding pocket money distribution, 51.1% of children in the case group fell into the high category, whereas the control group exhibited the highest proportion in the moderate category (39.4%), followed by the high category (31.9%) (**Table 1**).

Behavioral factors varied significantly between groups. A higher proportion of children in the control group engaged in high levels of physical activity (64.9%) compared to the case group (46.8%) (**Table 1**). Conversely, poor dietary habits were more prevalent in the case group (68.1%) than in the control group (52.1%), suggesting potential associations with nutritional status disparities (**Table 1**).

Family characteristics also exhibited notable differences. A higher proportion of mothers in the control group had a normal BMI (47.9%), whereas the case group showed an increased prevalence of maternal obesity, with obesity I at 35.1% and obesity II at 16.0%. Additionally, maternal nutritional knowledge was superior in the control group, with 88.3% demonstrating good nutritional awareness compared to 70.2% in the case group. Parenting styles were predominantly authoritative in both groups, but the prevalence was higher in the control group (97.8%) than in the case group (88.3%) (**Table 1**).

Associations between study variables and nutritional status among school-aged children

The associations between various study variables and the nutritional status of school-aged children in both the case and control groups are presented in **Table 2**. Socioeconomic factors showed significant associations with nutritional status. The distribution of pocket money was significantly associated with nutritional status (p=0.027), with a higher proportion of children in the case group receiving a high amount of pocket money (51.1%) compared to the control group (31.9%). Family income was also significantly associated with nutritional status (p=0.042), with most participants in both groups coming from families with very high income (85.1% in the case group and 89.4% in the control group) (**Table 2**).

Table 1. Socioeconomic characteristics, behavioral, and family factors of the study respondents

Variables	Category	Case (n=94)		Control (n=94)	
		Frequency	Percentage	Frequency	Percentage
Socioeconomic factors					
Pocket money	Low	18	19.1	27	28.7
	Moderate	28	29.8	37	39.4
	High	48	51.1	30	31.9
Family income	Moderate	1	1.1	5	5.3
	High	13	13.8	5	5.3
	Very high	80	85.1	84	89.4
Behavioral factors					
Sedentary activity	Low	50	53.2	33	35.1
	High	44	46.8	61	64.9
Dietary habit	Poor	64	68.1	49	52.1
	Good	30	31.9	45	47.9
Maternal factors					
Maternal body mass index	Underweight	3	3.2	2	2.1
	Normal	29	30.9	45	47.9
	Overweight risk	14	14.9	18	19.1
	Obesity I	33	35.1	26	27.7
	Obesity II	15	16.0	3	3.2
Maternal knowledge	Moderate	28	29.8	11	11.7
	Good	66	70.2	83	88.3
Parenting style	Authoritarian	6	6.4	1	1.1
	Authoritative	83	88.3	92	97.8
	Permissive	5	5.3	1	1.1

Behavioral factors such as sedentary activity and dietary habits were also significantly associated with nutritional status (**Table 2**). A higher proportion of children in the case group (53.2%) had low levels of sedentary activity compared to the control group (35.1%), with the difference being statistically significant (p=0.019). Additionally, dietary habits were associated with nutritional status (p=0.037), with a significantly higher proportion of children in the case group having poor dietary habits (68.1%) compared to the control group (52.1%) (**Table 2**).

Family factors demonstrated significant associations as well (**Table 2**). Maternal BMI was significantly associated with the nutritional status of children (p=0.011). A larger proportion of mothers in the case group had obesity I (35.1%) and obesity II (16.0%) compared to the control group (27.7% and 3.2%, respectively). Maternal knowledge about nutrition was strongly associated with children's nutritional status (p=0.004), with more mothers in the control group having good nutritional knowledge (88.3%) compared to the case group (70.2%). Parenting style was also significantly associated with nutritional status (p=0.035), with the majority of both groups being raised under an authoritative parenting style. However, the proportion was slightly higher in the control group (97.8%) compared to the case group (88.3%) (**Table 2**).

Table 2. Associations between socioeconomic, behavioral, and family factors with nutritional status among school-aged children

Variables	Nutritional status			p-value[a]
	Case (n=94)	Control (n=94)	Total (n=188)	
	n (%)	n (%)	n (%)	
Socioeconomic factors				
Pocket money				
Low	18 (19.1)	27 (28.7)	45 (23.9)	0.027*
Moderate	28 (29.8)	37 (39.4)	65 (34.6)	
High	48 (51.1)	30 (31.9)	78 (41.5)	
Family income				0.042*
Moderate	1 (1.1)	5 (5.3)	6 (3.2)	
High	13 (13.8)	5 (5.3)	18 (9.6)	
Very high	80 (85.1)	84 (89.4)	164 (87.2)	
Behavioral factors				
Sedentary activity				0.019*
Low	50 (53.2)	33 (35.1)	83 (44.1)	
High	44 (46.8)	61 (64.9)	105 (55.9)	
Dietary habit				0.037*
Poor	64 (68.1)	49 (52.1)	113 (60.1)	

Variables	Nutritional status			*p*-value[a]
	Case (n=94)	Control (n=94)	Total (n=188)	
	n (%)	n (%)	n (%)	
Good	30 (31.9)	45 (47.9)	75 (39.9)	
Maternal factors				
Maternal body mass index				0.011*
Underweight	3 (3.2)	2 (2.1)	5 (2.7)	
Normal	29 (30.9)	45 (47.9)	74 (39.4)	
Overweight risk	14 (14.9)	18 (19.1)	32 (17.0)	
Obesity I	33 (35.1)	26 (27.7)	59 (31.4)	
Obesity II	15 (16.0)	3 (3.2)	18 (9.6)	
Maternal knowledge				0.004**
Moderate	28 (29.8)	11 (11.7)	39 (20.7)	
Good	66 (70.2)	83 (88.3)	149 79.3)	
Parenting style				0.035*
Authoritarian	6 (6.4)	1 (1.1)	7 (3.7)	
Authoritative	83 (88.3)	92 (97.8)	175 (93.1)	
Permissive	5 (5.3)	1 (1.1)	6 (3.2)	

[a]Analyzed with Chi-squared test
*Statistically significant at $p<0.05$
**Statistically significant at $p<0.01$

Factors associated with nutritional risk in school-aged children

The determinants of nutritional status among school-aged children in an industrial area in Indonesia are presented in **Table 3**. The most dominant factor identified was poor dietary habits. Children with poor dietary habits were more than twice as likely to have poor nutritional status as those with good dietary habits, with an OR of 1.95 (95%CI: 1.08–4.54; p=0.026). After adjusting for other factors, this association remained significant with an aOR of 0.45 (95%CI: 0.22–0.90; p=0.024), suggesting that poor dietary habits are a decisive risk factor for poor nutritional status in children.

Another significant factor was maternal BMI, particularly in mothers with obesity class II (**Table 3**). Children whose mothers had obesity class II were less likely to experience poor nutritional status (OR: 0.12; 95%CI: 0.03–0.48; p=0.002), and this effect remained significant after adjustment (aOR: 0.12; 95%CI: 0.03–0.53; p=0.005). This highlights that maternal health, especially in terms of obesity, plays a significant role in determining the nutritional status of children. Maternal knowledge also had a significant impact on the nutritional status of children. Children whose mothers had good nutritional knowledge were less likely to have poor nutritional status (OR: 0.31; 95%CI: 0.14–0.67; p=0.003), and this association remained significant after adjustment (aOR: 0.29; 95%CI: 0.12–0.69; p=0.005). This suggests that improving maternal nutritional knowledge is a key strategy for preventing poor nutritional status in children.

Although pocket money was significantly associated with poor nutritional status in univariate analysis, this effect did not persist after adjusting for other factors (aOR for moderate and high pocket money were 2.162 and 2.092, respectively, with p>0.05), indicating that this factor may have a lesser influence compared to others mentioned. Similarly, sedentary activity did not show a significant relationship with poor nutritional status after adjustment (aOR: 0.703; p=0.703), indicating that the influence of physical activity on nutritional status may be more complex and possibly influenced by other unmeasured factors in this study.

Discussion

This study highlights the intricate relationship between socioeconomic determinants and the nutritional status of school-aged children in urban-industrial settings. Our findings emphasize the significant role of household income, parental weight, dietary patterns, physical activity, pocket money, sedentary behavior, and parenting style in shaping children's nutrition. These results align with previous studies that underscore the influence of socioeconomic factors on children's nutritional outcomes [11,26]. However, in urban-industrial environments like Batam, these socioeconomic influences are further complicated by rapid urbanization and evolving food environments, exacerbating the dual burden of malnutrition, manifesting as undernutrition and overnutrition.

Table 3. Multivariate binary logistic regression analysis of nutritional risk factors among school-aged children

Variables	Nutritional status		Crude odds ratio (OR) (95%CI)	*p*-value[a]	Adjusted OR (95%CI)	*p*-value[a]
	Case (n=94)	Control (n=94)				
Pocket money						
Low	18 (19.1)	27 (28.7)	Reference group (Ref.)		Ref.	
Moderate	28 (29.8)	37 (39.4)	2.40 (1.13–5.08)	0.022*	2.162 (0.92–5.09)	0.078
High	48 (51.1)	30 (31.9)	2.114 (1.08–4.13)	0.029*	2.092 (0.98–4.47)	0.057
Family income						
Moderate	1 (1.1)	5 (5.3)	4.762 (0.54–41.65)	0.158	4.158 (0.40–42.92)	0.232
High	13 (13.8)	5 (5.3)	0.366 (0.13–1.07)	0.067	0.452 (0.13–1.57)	0.212
Very High	80 (85.1)	84 (89.4)	Ref.		Ref.	
Sedentary activity						
Low	50 (53.2)	33 (35.1)	0.476 (0.27–0.86)	0.013*	0.703 (0.36–1.38)	0.703
High	44 (46.8)	61 (64.9)	Ref.		Ref.	
Dietary habit						
Poor	64 (68.1)	49 (52.1)	1.959 (1.08–4.55)	0.026*	0.451 (0.22–0.90)	0.024*
Good	30 (31.9)	45 (47.9)	Ref.		Ref.	
Maternal body mass index						
Underweight	3 (3.2)	2 (2.1)	0.430 (0.07–2.73)	0.371	0.404 (0.04–3.69)	0.422
Normal	29 (30.9)	45 (47.9)	Ref.		Ref.	
Overweight risk	14 (14.9)	18 (19.1)	0.829 (0.36–1.92)	0.661	0.783 (0.30–2.01)	0.611
Obesity I	33 (35.1)	26 (27.7)	0.508 (0.25–1.02)	0.056	0.495 (0.22–1.09)	0.080
Obesity II	15 (16.0)	3 (3.2)	0.129 (0.03–0.49)	0.002**	0.126 (0.03–0.53)	0.005**
Maternal knowledge						
Moderate	28 (29.8)	11 (11.7)	0.312 (0.14–0.67)	0.003**	0.294 (0.12–0.69)	0.005**
Good	66 (70.2)	83 (88.3)	Ref.		Ref.	
Parenting style						
Authoritarian	6 (6.4)	1 (1.1)	0.180 (0.02–1.58)	0.122	0.248 (0.02–2.47)	0.234
Authoritative	83 (88.3)	92 (97.8)	Ref.		Ref.	
Permissive	5 (5.3)	1 (1.1)	0.150 (0.01–1.27)	0.082	0.107 (0.01–1.07)	0.057

[a]Analyzed with Binary logistic regression multivariate test
*Statistically significant at $p<0.05$
**Statistically significant at $p<0.01$

A key finding of this study is the impact of household income on nutritional status. Children from lower-income households were more likely to experience undernutrition, reinforcing global evidence that poverty is a major contributor to food insecurity and inadequate dietary intake [27]. In contrast, children from higher-income households were more prone to overnutrition, particularly obesity. This trend reflects urbanization and the availability of inexpensive, calorie-dense processed foods, aligning with a study that shows how the abundance of unhealthy food options in industrialized cities contributes to rising obesity rates [5]. This dual burden of malnutrition highlights the need for integrated approaches that address both ends of the nutritional spectrum.

The role of maternal knowledge and parenting style in shaping children's nutritional outcomes is also noteworthy. A positive relationship between maternal nutrition knowledge and better child health has been well-documented, emphasizing the importance of educating mothers on food groups, balanced diets, and healthy eating habits [28,29]. In this study, authoritative parenting—characterized by warmth, support, and autonomy—was associated with healthier nutritional behaviors in children. These findings corroborate a previous study showing that authoritative parenting fosters better dietary choices and physical activity, improving children's overall health [24].

Sedentary behavior, particularly increased screen time, emerged as a significant concern. In urban-industrial settings like Batam, sedentary activities are becoming increasingly common, contributing to rising obesity rates. Our results confirm existing literature linking sedentary behavior with poor nutritional outcomes, including higher BMI and obesity [19]. Interventions aimed at reducing screen time and promoting physical activity are crucial in addressing the growing obesity epidemic among children.

Our findings also reinforce the significant influence of maternal BMI and nutritional knowledge on children's dietary patterns. Maternal BMI serves as a behavioral model, with children of mothers who have a higher BMI are more likely to mirror these dietary behaviors, resulting in similar nutritional risks [15]. Studies also show that children tend to exhibit unhealthy BMI patterns when their parents do as well, emphasizing the intergenerational transmission of health behaviors [30-32]. Furthermore, parents who model poor dietary habits, such as low breakfast and dinner frequency and excessive snack consumption, contribute to unhealthy food practices in children [33]. Additionally, maternal nutritional knowledge plays a pivotal role in guiding children's dietary habits. Mothers with better nutritional knowledge are more likely to encourage healthier eating practices in their children [34]. However, age-related maturity does not always correlate with better dietary guidance, and inadequate maternal knowledge has been linked to poor feeding practices, even in resource-rich households [35,36]. Addressing these knowledge gaps through targeted educational interventions could significantly improve children's nutrition.

Parenting style plays a critical role in shaping children's nutritional habits and sedentary behaviors. Studies have indicated that authoritative parenting, characterized by warmth and structure, promotes self-discipline, healthier dietary practices, and reduced screen time [33,37]. In contrast, authoritarian and permissive parenting styles are linked to poorer nutritional outcomes, such as increased intake of unhealthy foods and higher sedentary behavior [38]. Authoritative parenting has been shown to lower obesity risk and encourage healthier lifestyle choices, likely due to its balance of structure and autonomy [33]. Parents significantly influence children's food preferences and eating patterns, both through direct control and by modeling dietary behaviors [39-41]. Early-established dietary patterns often persist into adulthood, making a parent's feeding style and practices crucial in determining long-term nutritional outcomes [42]. These findings highlight the importance of promoting authoritative parenting through education to foster healthier eating habits in children.

Pocket money and sedentary activity are significant factors influencing children's dietary patterns. A previous study suggests that children with higher allowances tend to have greater access to unhealthy snacks, increasing their risk of weight gain and obesity, as financial independence encourages consumption of high-calorie foods [43]. While pocket money is often the main source of finances for children, its impact on dietary habits and weight gain, particularly among adolescents, remains underexplored [44]. Previous studies indicate that reducing pocket

money can lower soft drink consumption [44,45], and as discretionary spending increases, it correlates with higher BMI in children [46]. This finding underscores the potential of limiting pocket money as a strategy to mitigate childhood obesity. Additionally, higher levels of sedentary activity, particularly screen time, are strongly associated with lower physical activity and increased caloric intake, as sedentary behaviors often coincide with unhealthy food consumption [37,47,48]. These findings highlight the importance of managing both financial resources and screen time to promote healthier dietary habits and prevent obesity. Furthermore, balanced nutrition, including adequate nutrient intake and diverse food consumption, is essential to achieving and maintaining normal nutritional status, as supported by prior studies linking diet with nutritional outcomes [11,27,49].

Household income plays a crucial role in determining children's nutritional status, with strong links to food security and access to nutrient-rich diets. Low-income families often face significant food insecurity, leading to inadequate nutrition and poor health outcomes for children, including higher rates of stunting, wasting, and underweight among those from the lowest-income households [50-52]. However, higher family income does not always guarantee better nutrition, as a study has shown that increased income can sometimes lead to higher consumption of energy-dense, nutrient-poor foods like fast food [53]. This duality underscores the need for targeted interventions that alleviate poverty and promote healthy eating behaviors across all socioeconomic strata. Addressing poverty through policies that improve household purchasing power and ensure access to nutrient-dense foods can significantly enhance children's nutritional status. Simultaneously, public health initiatives should aim to educate families, regardless of income level, about the importance of balanced diets to prevent the dual burden of malnutrition.

The theoretical implications of this study support the Social Determinants of Health Theory, which emphasizes the importance of socioeconomic factors in shaping health outcomes [54]. Our findings provide valuable insights for policy interventions, such as nutrition education programs for mothers, regulating pocket money to reduce unhealthy food consumption, and promoting active lifestyles to reduce sedentary behavior. Targeted interventions that consider local socioeconomic and cultural contexts will be more effective in addressing the dual burden of malnutrition in urban-industrial settings like Batam.

Despite its contributions, this study has several limitations. The case-control design limits our ability to establish causal relationships between socioeconomic factors and children's nutritional status. Additionally, self-reported data from mothers may introduce bias, which affects the accuracy of reported nutritional knowledge and dietary habits. Future studies could benefit from longitudinal designs to assess causal relationships and use objective measures to assess dietary habits and maternal knowledge. Future studies could also explore community-based interventions to improve maternal nutritional knowledge and promote healthy eating habits in children. Further research into the interactions between socioeconomic and cultural factors in shaping eating habits will provide a deeper understanding of how local contexts influence children's nutritional status. Additionally, future research could assess the role of schools in supporting nutrition education and encouraging physical activity among children.

Conclusion

This study offers key insights into the complex factors influencing the nutritional status of school-aged children in urban-industrial settings. Our findings emphasize the dual burden of malnutrition, highlighting the significance of factors such as household income, parental nutritional knowledge, parenting style, and sedentary behaviors in shaping children's nutritional outcomes. The results reinforce the need for integrated, context-specific public health interventions that address both undernutrition and overnutrition, particularly in rapidly urbanizing areas. This study underscores the importance of improving nutrition knowledge, promoting healthy lifestyle practices, and creating supportive environments for balanced diets and physical activity to mitigate the long-term consequences of malnutrition. Future research should assess the effectiveness of targeted interventions in urban-industrial contexts to better inform policies aimed at improving children's health and well-being. By addressing these

interconnected factors, we can support the overall health, education, and economic prospects of children in such settings.

Ethics approval

Ethical approval for this study was obtained from the Ethics Committee of the Faculty of Medicine, Universitas Andalas, with approval number 108/UN.16.2/KEP-FK/2023. Written informed consent was obtained from all participants involved in the study.

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

This study used artificial intelligence (AI) tool, AI-based language model (ChatGPT) for language refinement (improving grammar, sentence structure, and readability of the manuscript). We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

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