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Title page

Prevalence and associated factors of overweight and obesity among primary school children: a cross-sectional study in Thanhhoa city, Vietnam

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Abstract

Objective: To determine the prevalence and associated factors of childhood overweight and obesity among primary school children in Thanhhoa city in 2021.

Design: Cross-sectional study.

Setting: Seven primary schools in Thanhhoa city, Vietnam.

Participants: 782 children and their parents.

Primary and secondary outcome measures: Two-stage cluster random sampling was used for selecting children and data were collected from January to February 2021. A self-administrated questionnaire was designed for children and their parents. Children's height and weight were measured and BMI-for-age z-scores were computed using the WHO Anthro software version 1.0.4. Data were analysed using R software version 4.1.1. The associations between potential factors and childhood overweight/obesity were analysed through univariate and multivariate logistic regression analyses. Variables were selected using the Bayesian Model Averaging method.

Results: The prevalence of overweight/obesity among primary school children in Thanhhoa city was 35.93% (overweight 21.61% and obesity 14.32%). Overweight boys and girls were nearly equal in proportions (22.52% and 20.78%, respectively) while the proportion of boys with obesity was four times as many as that of girls (23.86% and 5.62%, respectively). Gender was the factor significantly associated with childhood overweight/obesity. Boys had double the risk of being overweight/obese than girls (aOR=2.51, 95%CI: 1.84-3.43, p<0.0001). Other potential factors which may be associated with childhood overweight/obesity included mode of transport to school, the people living with the child, mother's occupation, father's education, eating confectionery, the total time of doing sports, and sedentary activities.

Conclusion: One in every three primary school children in Thanhhoa city were either overweight or obese. Parents, teachers, and policymakers can implement interventions in the aforementioned factors to reduce the rate of childhood obesity. In forthcoming years, longitudinal studies should be

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conducted to determine the causal relationships between potential factors and childhood overweight/obesity.

Keywords: associated factors, children, obesity, overweight, prevalence, Thanhhoa city, Vietnam.

Strengths and limitations of this study

- This is the first study conducted to investigate the prevalence and factors associated with overweight and obesity among primary school children in Thanhhoa province, Vietnam.
- In this study, by reason of the growing problems involving the reproducibility crisis in recent years, only p-values less than 0.001 were considered statistically significant.
- Causal relationships between factors and overweight/obesity cannot be determined because this is only a cross-sectional study. Using a self-administrated questionnaire can also bring about some biases.
- Data were only collected for primary school children aged 6-11 years in urban areas, not including rural areas and other age groups. Some factors such as birth weight and parental BMIs which may be strongly associated with childhood overweight/obesity were not collected.
- For children's dietary habits, we only gather information on the frequency. Further studies should focus on the intake of various kinds of foods that are strongly associated with overweight/obesity (portion size).

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Background

As per the World Health Organization (WHO), "overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health". In 2020, globally, there were approximately 39 million overweight/obese children under 5 years old. For children and adolescents aged 5-19 years, that figure was over 340 million in 2016 [1]. In 2017, overweight and obesity were the rationales behind the deaths of more than 4 million people. Globally, from 1975 to 2016, the prevalence of overweight/obesity among children and adolescents aged 5-19 years rocketed from 4% to 18% [2]. In the United States, there was a significant increase in the prevalence of children with overweight and class III obesity from 1999 to 2016 [3]. It is estimated that roughly 33% of children aged 6-11 years and 50% of adolescents aged 12-19 years will become overweight or obese in 2030 [4]. In Australia, 96% of children aged 5-14 years did not eat enough vegetables. More than 24% of them (746,000 children) were overweight (17%) or obese (7.7%) in 2017-2018 [5]. In almost all European countries, from 1999 to 2016, the prevalence of overweight/obesity among children aged 2-13 years was very high, especially in some Mediterranean countries. About 25% of obese children were severely obese. For children aged 6-9 years, the prevalence of severe obesity in boys was far higher than in girls [6, 7]. In Spain, in 2016, the prevalence of overweight/obesity among children aged 6-11 years was 39.9% for boys and 37.6% for girls [8]. In China, the prevalence of overweight and obesity among children and adolescents was 15.05% and 9.23% in Shandong province [9], 15.2% and 11.7% in Jiangsu province [10], and 12.7% and 4.9% in Changchun, Jilin province [11]. Generally, obesity in childhood is a worldwide epidemic requiring urgent actions and interventions [12].

In Vietnam, in 2017, there were approximately 7.4 million children under 5 and 26.2 million children and adolescents under 18 (constituting 8% and 28% of the total population, respectively). The sex ratio at birth was 112.2 baby boys per 100 baby girls. Nearly 5.5 million children had poor access to two following necessities or more: education, shelter, nutrition, health, water and sanitation, and social inclusion [13]. For children aged 3-6 years, the prevalence of overweight/obesity increased

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with age, especially in urban areas [14]. The prevalence of overweight/obesity among children and adolescents aged 5-19 years soared from 8.5% in 2010 to 19.0% in 2020 (26.8%, 18.3%, and 6.9% for urban, rural, and mountainous areas, respectively) [15].

From 2010 to now, globally, there has been a multitude of studies conducted to determine the prevalence and factors associated with overweight/obesity among children and adolescents [16-48]. The results from these studies showed that childhood obesity should be a problematic matter of concern by virtue of the high prevalence of overweight/obesity among children and adolescents. Risk factors significantly associated with overweight/obesity among children include gender [17-22], age [18, 19, 21], birth order [19], overweight at birth [19], the number of siblings [19, 23], residence (urban/rural) [21, 22, 24], school type (public/private) [18, 25], mode of transport to school [17, 26], father/mother's education [18, 26, 27], father/mother's occupation [17, 19, 24], parental overweight/obesity or BMIs [18, 19, 24, 29, 30], food intakes [29], dinner time [26], fast food, sweets, sugary/sweetened drinks [17, 22, 25, 31], eating vegetables/fruits [29, 32], physical activities (exercises/playing sports) [20, 29], and sedentary activities (watching television, computer game playing, sleeping) [17, 19, 29, 31, 32]. In Vietnam, only two previous studies were conducted in Haiphong city, Vietnam to measure the prevalence of overweight/obesity among primary school children [33, 34]. Thanhhoa is a province located in the central part of Vietnam. Up to now, there is no study conducted in this province to determine associated factors and the prevalence of overweight/obesity among children. This research was conducted to determine the prevalence and associated factors of childhood overweight/obesity among primary school children in Thanhhoa city in 2021.

Methods

This cross-sectional, paper-based survey was carried out in Thanhhoa city, Vietnam from Jan 01 to Feb 28, 2021. In the light of numerous difficulties in directly interviewing children, a self-administrated questionnaire was designed for both children and their parents. Based on the questionnaires of previous studies [19, 25, 27, 29-32], questions were selected, amended, and

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translated into Vietnamese. To validate the questionnaire, a pilot study was conducted with the participation of 20 children and their parents. Furthermore, five senior lecturers of the University of Medicine and Pharmacy at Ho Chi Minh City aided the research team to review the questionnaire. The final questionnaire which can be seen in the Supplemental File included three main parts. Part 1 included questions on socio-demographic characteristics of children and parents. Part 2 focused on investigating the dietary habits of children. Part 3 included questions in relation to children's physical and sedentary activities.

Supplemental File

Patient and public involvement

No patient involved.

The sample size

The study population was primary school children in Thanhhoa city (grade one to five). There are 48 primary schools and about 35,000 primary school students in this city. The sample size was computed using the following formula:

$$n = Z^2_{1-\alpha/2}\frac{p(1-p)}{d^2}\text{Deff}$$

- Deff=1+ICCx(n-1)=1+0.05x(30-1)=2.45 (ICC: interclass correlation for the statistic (ICC=0.05), n=the average size of the clusters (approximately 30 students/class)).

- p=0.221 (from a study conducted in Haiphong city in 2018 [34])

- Z=1.96 (α=0.05), d=0.05 (because 0.1<p<0.3)

The minimum sample size was 700 children. To increase this study's validity and generalizability, a total of 986 children were approached. The response rate was 85.40%. However, after checking data-collection forms, 53 children were excluded from this research because of missing values (Questions in the data-collection forms were not fully answered). The final sample size was 782 children.

Data collection

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In Thanhhoa city, seven schools were randomly selected for investigation. Data were collected with the approval of the headmasters/headmistresses of these primary schools. In each school, for each grade, one class was randomly selected. All students in these selected classes were recruited in this research, excluding children with amputations or those contracting any chronic/acute health conditions. With the assistance of teachers, each student was given one data-collection form and one written consent form. Students took these two forms, went home, and filled in these forms in company with their parents. Then, the teachers collected forms from their students. A week later, data collectors came back to selected classes and received data-collection forms and written consent forms from teachers.

For students having both forms, their height and weight were measured with the aid of the teachers during playtime. Weight and height were measured for children wearing light clothing without shoes. Weight was measured in kilograms (kg) with the Microlife Weight Scale 50A (manufactured in Sweden) and rounded to the nearest 0.1kg. Each child was measured twice and his/her weight was the average weight. If the difference between the two measurements was more than 0.1kg, a third measurement was carried out. Height was also measured twice with a SECA 222 (manufactured in Germany) and recorded in meters (m) with an accuracy of 0.01m.

Data analysis

The WHO Anthro software version 1.0.4 was employed for anthropometric calculation. BAZs (BMI-for-age z-scores) were used to categorized children into groups: underweight, normal, overweight, and obese. A child was categorized as underweight, overweight, and obese if BAZ<-2SD, 2SD>BAZ>1SD, and BAZ≥2 SD, respectively.

Data were analyzed using R software version 4.1.1. The correlations between factors (independent variables) and nutritional status of children were analyzed using the Chi-squared test and Fisher's exact test (when at least one expected value was less than 5). All variables with p-values<0.2 were included in the univariate logistic regression analyses. Variables in the multivariate logistic regression model were selected using the Bayesian Model Averaging method. This model

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was used to adjust for confounding and explore the associations between factors (independent variables) and the nutritional status of children (dependent variable - a binary variable indicating whether or not children were overweight/obese). The goodness of fit of the multivariate logistic model was assessed using the Hosmer–Lemeshow test and the value of area under the curve (AUC). By reason of the growing problems involving low reproducibility probability in recent years (replication crisis), in this study, a factor was only regarded as a statistically significant variable if its p-value was lower than 0.001.

Results

The average age of children was 101.02±16.33 (months). More than 71% of children came from urban areas and public schools. Only 231 children (29.54%) went to school by themselves (walking: 9.97% and cycling: 19.57%). Most of the children lived with both parents (88.87%) and another sibling (73.02%). The parental education levels were primarily high school and university (father: 77.36% and mother: 79.15%). The monthly income of most families was lower than 856.56 US$ (76.22%). Overweight boys and girls were nearly equal in proportions (22.52% and 20.78%, respectively). However, the proportion of boys with obesity (23.86%) was four times as many as that of girls (5.62%). Overall, the prevalence of overweight/obesity among primary school children in Thanhhoa city was 35.93% (overweight 21.61% and obesity 14.32%) (Table 1 and Fig 1).

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Table 1. Socio-demographic characteristics of children/parents and nutritional status for each children group

No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
1	**Gender**						
	Male	373 (47.70)	84 (10.74)	89 (11.38)	173 (22.12)	200 (25.58)	<0.0001
	Female	409 (52.30)	85 (10.87)	23 (2.94)	108 (13.81)	301 (38.49)	
2	**Age (months)**						
	72 to 83	145 (18.54)	31 (3.96)	24 (3.07)	55 (7.03)	90 (11.51)	0.2292
	84 to 95	158 (20.20)	30 (3.84)	22 (2.81)	52 (6.65)	106 (13.55)	
	96 to 107	178 (22.76)	41 (5.24)	34 (4.35)	75 (9.59)	103 (13.17)	
	108 to 119	170 (21.74)	35 (4.48)	24 (3.07)	59 (7.54)	111 (14.19)	
	120 to 131	131 (16.75)	32 (4.09)	8 (1.02)	40 (5.12)	91 (11.64)	
3	**Grade**						
	1	145 (18.54)	31 (3.96)	24 (3.07)	55 (7.03)	90 (11.51)	0.2045
	2	159 (20.33)	30 (3.84)	22 (2.81)	52 (6.65)	107 (13.68	
	3	177 (22.63)	41 (5.24)	34 (4.35)	75 (9.59)	102 (13.04)	
	4	170 (21.74)	35 (4.48)	24 (3.07)	59 (7.54)	111 (14.19)	

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	5	131 (16.75)	32 (4.09)	8 (1.02)	40 (5.12)	91 (11.64)	
4	**Area**						
	Urban	562 (71.87)	121 (15.47)	84 (10.74)	205 (26.21)	357 (45.65)	0.6721
	Suburb	220 (28.13)	48 (6.14)	28 (3.58)	76 (9.72)	144 (18.41)	
5	**School type**						
	Public	557 (71.23)	119 (15.22)	71 (9.08)	190 (24.30)	367 (46.93)	0.1121
	Private	225 (28.77)	50 (6.39)	41 (5.24)	91 (11.64)	134 (17.14)	
6	**The number of children in the family**						
	1	62 (7.93)	17 (2.17)	15 (1.92)	32 (4.09)	30 (3.84)	0.0146*
	2	571 (73.02)	118 (15.09)	81 (10.36)	199 (25.45)	372 (47.57)	
	3	125 (15.98)	28 (3.58)	13 (1.66)	41 (5.24)	84 (10.74)	
	4	18 (2.30)	6 (0.77)	3 (0.38)	9 (1.15)	9 (1.15)	
	5	6 (0.77)	0 (0.00)	0 (0.00)	0 (0.00)	6 (0.77)	
7	**Mode of transport to school**						
	On foot	78 (9.97)	16 (2.05)	9 (1.15)	25 (3.20)	53 (6.78)	0.0416

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	Bicycle	153 (19.57)	26 (3.32)	17 (2.17)	43 (5.50)	110 (14.07)	
	Motorbike/car/bus	551 (70.46)	127 (16.24)	86 (11.00)	213 (27.24)	338 (43.22)	
8	**Father's education**						
	Under secondary	23 (2.94)	2 (0.26)	0 (0.00)	2 (0.26)	21 (2.69)	0.0390
	Secondary	74 (9.46)	19 (2.43)	10 (1.28)	29 (3.71)	45 (5.75)	
	High school	238 (30.43)	48 (6.14)	30 (3.84)	78 (9.97)	160 (20.46)	
	University	367 (46.93)	83 (10.61)	59 (7.54)	142 (18.16)	225 (28.77)	
	Post-university	80 (10.23)	17 (2.17)	13 (1.66)	30 (3.84)	50 (6.39)	
9	**Father's occupation**						
	Blue-collar worker	515 (65.86)	107 (13.68)	66 (8.44)	173 (22.12)	342 (43.73)	0.0693
	White-collar worker	267 (34.14)	62 (7.93)	46 (5.88)	108 (13.81)	159 (20.33)	
10	**Mother's education**						
	Under secondary	18 (2.30)	2 (0.26)	0 (0.00)	2 (0.26)	16 (2.05)	0.0851
	Secondary	81 (10.36)	18 (2.30)	8 (1.02)	26 (3.32)	55 (7.03)	
	High school	215 (27.49)	45 (5.75)	26 (3.32)	71 (9.08)	144 (18.41)	

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	University	404 (51.66)	90 (11.51)	69 (8.82)	159 (20.33)	245 (31.33)	
	Post-university	64 (8.18)	14 (1.79)	9 (1.15)	23 (2.94)	41 (5.24)	
11	**Mother's occupation**						
	Blue-collar worker	438 (56.01)	82 (10.49)	54 (6.91)	136 (17.39)	302 (38.62)	0.0017
	White-collar worker	344 (43.99)	87 (11.13)	58 (7.42)	145 (18.54)	199 (25.45)	
12	**People living with the child**						
	Mother and father	695 (88.87)	143 (18.29)	95 (12.15)	238 (30.43)	457 (58.44)	0.0021*
	Only father	9 (1.15)	4 (0.51)	4 (0.51)	8 (1.02)	1 (0.13)	
	Only mother	36 (4.60)	11 (1.41)	6 (0.77)	17 (2.17)	19 (2.43)	
	Others	42 (5.37)	11 (1.41)	7 (0.90)	18 (2.30)	24 (3.07)	
13	**Family income** (M: million Vietnam dongs, 10,000,000 Vietnam dongs = 428.28US$)						
	< 10M	284 (36.32)	52 (6.65)	29 (3.71)	81 (10.36)	203 (25.96)	0.0011
	10M - 19.99M	312 (39.90)	70 (8.95)	44 (5.63)	114 (14.58)	198 (25.32)	
	20M - 29.99M	131 (16.75)	36 (4.60)	27 (3.45)	63 (8.06)	68 (8.70)	
	30M or more	55 (7.03)	11 (1.41)	12 (1.53)	23 (2.94)	32 (4.09)	

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	Total	**782 (100)**	**169 (21.61)**	**112 (14.32)**	**281 (35.93)**	**501 (64.07)**	
p-values were calculated using the Chi-squared test and Fisher's exact test. *: using Fisher's exact test Blue-collar workers (people do work needing strength or physical skill rather than office work, for example, farmers, drivers, traders) White-collar workers (people who work in offices, doing work needings mental rather than physical effort, for example, doctors, teachers)							

Figure 1. The nutritional status of children classified by gender

Most of the children had breakfast, lunch, and dinner daily. Only 44 children (5.63%) usually had a meal after 20:00. About three-fifths of children ate vegetables every day/almost every day. The proportions of children usually eating confectionery and fast food were low (13.81% and 2.69%, respectively). Only 26 children (3.32%) drank soda/soft drinks more than five days per week. Among factors related to dietary characteristics of children, eating confectionery can be a potential factor associated with childhood overweight/obesity (p=0.0172, *Chi-squared test*) (Table 2).

Table 2. Dietary habits of children and nutritional status for each children group

No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
1	**Breakfast**						
	Never	21 (2.69)	3 (0.38)	4 (0.51)	7 (0.90)	14 (1.79)	0.9312

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	Rarely	15 (1.92)	4 (0.51)	2 (0.26)	6 (0.77)	9 (1.15)	
	Sometimes	25 (3.20)	5 (0.64)	4 (0.51)	9 (1.15)	16 (2.05)	
	Usually	28 (3.58)	6 (0.77)	2 (0.26)	8 (1.02)	20 (2.56)	
	Every day	693 (88.62)	151 (19.31)	100 (12.79)	251 (32.10)	442 (56.52)	
2	**Lunch**						
	Never	20 (2.56)	5 (0.64)	3 (0.38)	8 (1.02)	12 (1.53)	0.8795*
	Rarely	11 (1.41)	2 (0.26)	1 (0.13)	3 (0.38)	8 (1.02)	
	Sometimes	8 (1.02)	1 (0.13)	2 (0.26)	3 (0.38)	5 (0.64)	
	Usually	13 (1.66)	3 (0.38)	3 (0.38)	6 (0.77)	7 (0.90)	
	Every day	730 (93.35)	158 (20.20)	103 (13.17)	261 (33.38)	469 (59.97)	
3	**Dinner**						
	Never	30 (3.84)	5 (0.64)	3 (0.38)	8 (1.02)	22 (2.81)	0.6717*
	Rarely	11 (1.41)	3 (0.38)	2 (0.26)	5 (0.64)	6 (0.77)	
	Sometimes	9 (1.15)	1 (0.13)	1 (0.13)	2 (0.26)	7 (0.90)	
	Usually	19 (2.43)	3 (0.38)	3 (0.38)	6 (0.77)	13 (1.66)	

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	Every day	713 (91.18)	157 (20.08)	103 (13.17)	260 (33.25)	453 (57.93)	
4	**Eating after 20:00**						
	Never/Rarely	453 (57.93)	95 (12.15)	69 (8.82)	164 (20.97)	289 (36.96)	0.334
	Sometimes	285 (36.45)	62 (7.93)	35 (4.48)	97 (12.40)	188 (24.04)	
	Usually/Every day	44 (5.63)	12 (1.53)	8 (1.02)	20 (2.56)	24 (3.07)	
5	**Eating vegetables**						
	Never/Rarely	71 (9.08)	17 (2.17)	10 (1.28)	27 (3.45)	44 (5.63)	0.4536
	Sometimes	250 (31.97)	53 (6.78)	29 (3.71)	82 (10.49)	168 (21.48)	
	Usually/Every day	461 (58.95)	99 (12.66)	73 (9.34)	172 (21.99)	289 (36.96)	
6	**Eating confectionery/sweet foods**						
	Never/Rarely	125 (15.98)	34 (4.35)	24 (3.07)	58 (7.42)	67 (8.57)	0.0172
	Sometimes	549 (70.20)	115 (14.71)	76 (9.72)	191 (24.42)	358 (45.78)	
	Usually/Every day	108 (13.81)	20 (2.56)	12 (1.53)	32 (4.09)	76 (9.72)	
7	**Eating fast food**						
	Never/Rarely	332 (42.46)	70 (8.95)	52 (6.65)	122 (15.60)	210 (26.85)	0.4471

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	Sometimes	429 (54.86)	93 (11.89)	56 (7.16)	149 (19.05)	280 (35.81)	
	Usually/Every day	21 (2.69)	6 (0.77)	4 (0.51)	10 (1.28)	11 (1.41)	
8	**Drinking soda, soft drinks**						
	Never/Rarely	336 (42.97)	69 (8.82)	57 (7.29)	126 (16.11)	210 (26.85)	0.3225
	Sometimes	420 (53.71)	97 (12.40)	52 (6.65)	149 (19.05)	271 (34.65)	
	Usually/Every day	26 (3.32)	3 (0.38)	3 (0.38)	6 (0.77)	20 (2.56)	

p-values were calculated using the Chi-squared test and Fisher's exact test. *: using Fisher's exact test

Rarely: 1-3 days/month or one day/week, Sometimes: 2-4 days/week, Usually: 5-6 days/week.

Most of the children assisted their parents in doing household chores (86.57%). More than 37% of children did not play sports. Two-fifths of children played sports from one to four times per week. The average time of doing sports among children was 1.20 ± 2.28 hours per week. For sedentary activities, the proportion of children using computers/laptops for recreational activities was extremely low. The number of children watching television and using phones/tablets more than 3 hours per day was negligible. Only 62 children (7.92%) read books, newspapers, or magazines more than an hour per day. In general, the total time for sedentary activities of almost all children was lower than two hours per day (Table 3).

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Table 3. Physical and sedentary activities of children and nutritional status for each children group

No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
1	**Doing household chores**						
	Yes	677 (86.57)	151 (19.31)	91 (11.64)	242 (30.95)	435 (55.63)	0.8664
	No	105 (13.43)	18 (2.30)	21 (2.69)	39 (4.99)	66 (8.44)	
2	**Playing indoor/outdoor**						
	Indoor	432 (55.24)	106 (13.55)	62 (7.93)	168 (21.48)	264 (33.76)	0.0660
	Outdoor	350 (44.76)	63 (8.06)	50 (6.39)	113 (14.45)	237 (30.31)	
3	**Playing sports**						
	Yes	491 (62.79)	114 (14.58)	82 (10.49)	196 (25.06)	295 (37.72)	0.0033
	No	291 (37.21)	55 (7.03)	30 (3.84)	85 (10.87)	206 (26.34)	
4	**The number of times playing sports per week**						
	Not playing sports	291 (37.21)	55 (7.03)	30 (3.84)	85 (10.87)	206 (26.34)	0.0430
	1 to 2 times	187 (23.91)	43 (5.50)	36 (4.60)	79 (10.10)	108 (13.81)	
	3 to 4 times	146 (18.67)	37 (4.73)	20 (2.56)	57 (7.29)	89 (11.38)	
	5 to 6 times	69 (8.82)	16 (2.05)	10 (1.28)	26 (3.32)	43 (5.50)	

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	7 times or more	89 (11.38)	18 (2.30)	16 (2.05)	34 (4.35)	55 (7.03)	
5	**The total time of playing sports per week**						
	Not playing sports	291 (37.21)	55 (7.03)	30 (3.84)	85 (10.87)	206 (26.34)	0.0050
	Less than 1h	102 (13.04)	21 (2.69)	20 (2.56)	41 (5.24)	61 (7.80)	
	1h - less than 2h	172 (21.99)	29 (3.71)	28 (3.58)	57 (7.29)	115 (14.71)	
	2h - less than 3h	87 (11.13)	32 (4.09)	10 (1.28)	42 (5.37)	45 (5.75)	
	3h - less than 4h	48 (6.14)	12 (1.53)	6 (0.77)	18 (2.30)	30 (3.84)	
	4h or more	82 (10.49)	20 (2.56)	18 (2.30)	38 (4.86)	44 (5.63)	
6	**Watching television**						
	Never	168 (21.48)	33 (4.22)	14 (1.79)	47 (6.01)	121 (15.47)	0.0208*
	Less than 1h/day	402 (51.41)	92 (11.76)	70 (8.95)	162 (20.72)	240 (30.69)	
	From 1h to 3h/day	210 (26.85)	43 (5.50)	28 (3.58)	71 (9.08)	139 (17.77)	
	More than 3h/day	2 (0.26)	1 (0.13)	0 (0.00)	1 (0.13)	1 (0.13)	
7	**Using computers, laptops**						
	Never	687 (87.85)	141 (18.03)	99 (12.66)	240 (30.69)	447 (57.16)	0.1486*

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	Less than 1h/day	78 (9.97)	24 (3.07)	11 (1.41)	35 (4.48)	43 (5.50)	
	From 1h to 3h/day	16 (2.05)	3 (0.38)	2 (0.26)	5 (0.64)	11 (1.41)	
	More than 3h/day	1 (0.13)	1 (0.13)	0 (0.00)	1 (0.13)	0 (0.00)	
8	**Using phones, tablets**						
	Never	451 (57.67)	94 (12.02)	70 (8.95)	164 (20.97)	287 (36.70)	0.562
	Less than 1h/day	264 (33.76)	59 (7.54)	36 (4.60)	95 (12.15)	169 (21.61)	
	From 1h to 3h/day	66 (8.44)	15 (1.92)	6 (0.77)	21 (2.69)	45 (5.75)	
	More than 3h/day	1 (0.13)	1 (0.13)	0 (0.00)	1 (0.13)	0 (0.00)	
9	**Reading books, newspapers, magazines**						
	Never	400 (51.15)	70 (8.95)	63 (8.06)	133 (17.01)	267 (34.14)	0.0613
	Less than 1h/day	320 (40.92)	83 (10.61)	40 (5.12)	123 (15.73)	197 (25.19)	
	From 1h to 3h/day	59 (7.54)	14 (1.79)	8 (1.02)	22 (2.81)	37 (4.73)	
	More than 3h/day	3 (0.38)	2 (0.26)	1 (0.13)	3 (0.38)	0 (0.00)	
10	**The total time of sedentary activities**						
	Less than 1h/day	314 (40.15)	59 (7.54)	43 (5.50)	102 (13.04)	212 (27.11)	0.1763

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No	Factor	The number of children (%)					p-value
		Total	Overweight	Obesity	Overweight/Obesity	Underweight/Normal	
	From 1h to 2h/day	398 (50.90)	85 (10.87)	64 (8.18)	149 (19.05)	249 (31.84)	
	More than 2h/day	70 (8.95)	25 (3.20)	5 (0.64)	30 (3.84)	40 (5.12)	
	Total	**782 (100)**	**169 (21.61)**	**112 (14.32)**	**281 (35.93)**	**501 (64.07)**	
p-values were calculated using the Chi-squared test and Fisher's exact test. *: using Fisher's exact test							

The results from the univariate logistic regression model show that childhood overweight/obesity can be associated with gender (p<0.0001), using motorbike/car/bus to go to school (p=0.017), children living with only dad (p=0.0102), fathers with under secondary education level (p=0.030), mother's occupation (p=0.0014), usually eating confectionery (p=0.0092), the total time of doing sports per week (p=0.0076), and the total time for sedentary activities per day (p=0.0348). The results from the multivariate logistic model show that gender, mode of transport to school, people living with the child, and mother's occupation were several factors associated with childhood overweight/obesity. Gender was the factor significantly associated with childhood overweight/obesity with p<0.0001. Hosmer-Lemeshow goodness of fit test for the multivariate logistic regression model showed that this model can adequately fit the data (X-squared = 2.5765, df = 8, p-value = 0.9581). The area under the curve (AUC) of the multivariate logistic regression model was 0.6607 (Table 4 and Fig 2).

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Table 4. Factors associated with overweight and obesity among primary school children in Thanhhoa city

No	Factor	Univariate logistic regression		Multivariate logistic regression	
		OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
1	**Gender** (reference: Female)				
	Male	2.41 (1.79, 3.26)	<0.0001	2.51 (1.84, 3.43)	<0.0001
2	**School** (reference: Private)				
	Public	0.76 (0.55, 1.05)	0.0952		
3	**The number of children in the family** (continuous variable)				
	Per children	0.80 (0.62, 1.01)	0.0694		
4	**Mode of transport to school** (reference: Bicycle)				
	On foot	1.21 (0.66, 2.17)	0.534	0.96 (0.51, 1.76)	0.8866
	Motorbike/car/bus	1.61 (1.10, 2.40)	0.017	1.56 (1.04, 2.37)	0.0327
5	**People living with the child** (reference: Both mother and father)				
	Only father	15.36 (2.80, 285.83)	0.0102	12.56 (2.17, 238.47)	0.0195
	Only mother	1.72 (0.87, 3.37)	0.1149	2.02 (0.99, 4.08)	0.0493
	Others (grandparents...)	1.44 (0.76, 2.70)	0.2572	1.29 (0.67, 2.47)	0.4348
6	**Father's education** (reference: High school)				

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No	Factor	Univariate logistic regression		Multivariate logistic regression	
		OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
	Under secondary	0.20 (0.03, 0.69)	0.030		
	Secondary	1.32 (0.77, 2.26)	0.311		
	University	1.29 (0.92, 1.83)	0.140		
	Post university	1.23 (0.72, 2.08)	0.440		
7	**Father's occupation** (reference: Blue-collar worker)				
	White-collar worker	1.34 (0.99, 1.82)	0.0584		
8	**Mother's occupation** (reference: Blue-collar worker)				
	White-collar worker	1.62 (1.21, 2.17)	0.0014	1.59 (1.17, 2.16)	0.0033
9	**Mother's education** (reference: High school)				
	Under secondary	0.25 (0.04, 0.92)	0.0724		
	Secondary	0.96 (0.55, 1.64)	0.8799		
	University	1.32 (0.93, 1.87)	0.1210		
	Post university	1.14 (0.63, 2.03)	0.6651		
10	**Family income** (continuous variable) (1,000,000 Vietnam dongs = 42.828US$)				
	Per million Vietnam dong	1.01 (1.00, 1.02)	0.0563		

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No	Factor	Univariate logistic regression		Multivariate logistic regression	
		OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
11	**Eating confectionery/sweet foods** (reference: Never/Rarely)				
	Sometimes	0.62 (0.42, 0.91)	0.0158		
	Usually/Every day	0.49 (0.28, 0.83)	0.0092		
12	**The time of doing sports per week** (continuous variable)				
	Per hours	1.09 (1.02, 1.16)	0.0076		
13	**The time for sedentary activities per day** (continuous variable)				
	Per hours	1.19 (1.01, 1.41)	0.0348		
14	**Playing** (reference: Indoor)				
	Outdoor	0.75 (0.56, 1.01)	0.0559		
The multivariate logistic regression model was chosen using the Bayesian Model Averaging method.					

Figure 2. The receiver operating characteristic (ROC) curve analysis for the multivariate logistic regression model

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Discussion

This is the first study conducted in Thanhhoa city to determine the prevalence and risk factors associated with overweight/obesity among primary school children. The results show that among 782 investigated children, 281 children (35.93%) were overweight/obese (overweight 21.61% and obese 14.32%), congruent with the results of several studies conducted in urban areas/cities in Port Said (2011): 31.2% [35]; Uberaba, Brazil (2012-2013): 32.3% [36]; Ankara, Turkey (2015): 35.9% [27]; and New Zealand (2017-2018): 31.9% [37]. The prevalence of overweight/obesity among primary school children in Thanhhoa is lower than the results of Hochiminh city, Vietnam (2014-2015): 55.6% [38] but far higher than the results of Rikuzentakata, Japan (2013): 7.8% [39]; Guangzhou, China (2014): 18.2% [18]; Chocó, Colombia (2015): 13.2% [40]; Lomé, Togo (2015): 7.1% [32]; Nepal (2017): 25.7% [17]; and Abidjan, Ivory Coast (2018): 10.2% [41]. Therefore, the epidemic of overweight/obesity among children can be regarded as a matter of concern in Thanhhoa city.

The results from the multivariate logistic regression model show that gender was the risk factor significantly associated with overweight/obesity among children in Thanhhoa. The odds of being overweight/obese among boys was 2.51 (1.84-3.43) times more likely when compared to girls ($p<0.0001$). This result is in line with the results from studies conducted in urban Nepal (male: aOR=2.21, 95%CI: 1.38–3.53, $p<0.001$) [17]; urban China (male: aOR=2.30, 95%CI: 2.00-2.65) [42]; Montenegro (female: aOR=0.64, 95%CI: 0.53-0.78, $p<0.001$) [19]; Guangzhou, China (male: aOR=2.56, 95%CI: 2.24–2.93, $p<0.001$) [18]; Changchun, China (male: aOR=1.91, 95%CI: 1.48-2.47, $p<0.001$) [11]. In Iran, the prevalence of girls with obesity was also significantly lower than that of boys ($p=0.007$) [43]. By contrast, in some other countries, girls were more likely to be overweight/obese than boys, for example in Ethiopia (female: OR=3.23, 95%CI: 2.03-5.13) [28]. In Ivory Coast, in comparison with boys, overweight and obesity were also common among girls ($p=0.001$) [41]. However, in Brazil, there was no difference in obesity prevalence between boys and girls (PR=1.06, 95%CI: 0.81-1.40, $p>0.05$) [44].

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There were several possible rationales behind the higher prevalence of overweight/obesity among boys than girls in Thanhhoa city. Firstly, in comparison with girls, the average time (minutes per day) for sedentary activities of boys (73.12) was higher than girls (67.77), including watching television: 37.45 and 32.28, using computers/phones/tablets: 19.65 and 16.79, respectively. This reason was also reported in previous studies in Montenegro [19] and Columbia [45]. In addition, in many countries, male chauvinism is still rife. In Vietnam, many parents hold a belief that girls are less valuable than boys and strong fertility desire commonly appears in families without sons. As a result, parents usually cosset their sons more than their daughters. In general, boys usually eat more than girls since the former consume more calories than the latter. Boys can be pampered with unhealthy food such as fast food, confectionery, and soda, thereby increasing the risk of being overweight/obese. In this study, we only asked children's parents about the frequency of consuming fast food, confectionery, and soda. Future studies should focus on the total intakes of these unhealthy foods to assess their effects on children's nutritional status more specifically.

From the multivariate logistic regression model, three other risk factors which could be associated with childhood overweight/obesity included transportation to school, the mother's occupation, and the people living with the child. In Nepal, mother's occupation was the risk factor significantly associated with childhood overweight/obesity (professions: aOR=1.34, 95%CI: 1.02–4.05, p<0.001) [17]. Regarding transportation to school, in Thanhhoa, only 29.54% of children walked/cycled to school, far lower than the result of Lomé, Togo (90.1%) [32] and Port Said city (47.3%) [35]. In Thanhhoa, children going to school with the aid of parents/other people (using motorbikes/cars/buses) had more risks of being overweight/obese than those going to school by themselves (walking/using bicycles) (aOR=1.56, p=0.033). In Nepal, children using school buses and own/public vehicles had a double risk of being overweight/obese than those walking to school with p-values<0.05 (aOR (95%CI) = 2.3 (1.1-4.7) and 2.4 (1.2-6.7), respectively) [17]. For the factor involving people living with the child, 88.87% of children in Thanhhoa lived with both parents, similar to the result of Montenegro (91.11%) [19]. By virtue of the low divorce rate, the number of

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children living with only a father/mother was extremely low (9 and 36 cases, respectively). This can affect the accuracy and the reproducibility of results involving this factor. It is necessary to carry out other studies to re-analyze the effect of this factor on the prevalence of being overweight/obese among children.

Besides the four abovementioned factors, the results from univariate logistic regression show that father's education, confectionery consumption, the time of doing sports (per week), and the time for sedentary activities (per day) can be risk factors associated with overweight/obesity among children in Thanhhoa city with p-values < 0.05. In Hanoi, Vietnam, the father's education may be a factor associated with the prevalence of overweight/obesity among children (college/university level: aOR=0.65, p=0.05) [29]. For sugary/sweetened foods, the proportion of children eating confectionery more than five times/week in Thanhhoa was 13.81%, in line with the result of Nepal (16.9%) [17] but lower than the result of Sharjah, UAE (54.6% of children eating candies every day/almost every day) [31]. In lieu of overweight/obese children having a higher consumption of confectionery, our results showed a reverse association. In comparison with children never/rarely eating confectionery, the odds of being overweight/obese were 38% (OR=0.62, 95%CI: 0.42-0.91) and 51% (OR=0.49, 95%CI: 0.28-0.83) lower for children sometimes and usually/every day eating confectionery, respectively, in line with the result of a systematic review and meta-analysis [46]. Although eating chocolate and sugar candies may not have pernicious effects on children's health [47], excessive consumption of these types of foods is unnecessary and detrimental in some cases. By way of illustration, for children having a sweet tooth, they can eat numerous kinds of confectionery instead of meat, fish, and vegetables in main meals such as lunch and dinner. As a result, children can suffer from deficiencies in numerous beneficial minerals, vitamins, and other vital nutrients in meat, fish, or vegetables.

Regarding sedentary activities, in Thanhhoa, the odds ratio for being overweight/obese increased 19% for a one-hour increase in the total time of sedentary activities (p=0.0348). In Nepal, sedentary activities were the factor significantly associated with overweight/obesity among children:

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children spending > 2 hours a day on weekends on sedentary activities were three times more likely to be overweight/obese than those spending ≤ 2 hours a day on weekends (aOR=3.01, 95%CI: 1.20-7.29, p<0.05) [17]. Several previous studies having the same results include Lomé, Togo: watching television on weekends > 4 hours (aOR=3.8, 95%CI: 1.2-12.0, p=0.02) [32], Montenegro: computer game playing (per hour daily) (aOR=1.11, 95%CI: 1.00-1.24, p=0.049) [19], and Karachi, Pakistan: watching television > 2 hours a day (aOR=6.42, 95%CI: 4.32-9.54, p<0.0001) [48]. For physical activities, playing sports was not the predilection of many primary school children in Thanhhoa when 37.21% of children did not play sports and 83.37% of them spent less than three hours per week on physical activities. Only 25.58% of children played sports more than three times/week, far lower than the result of China (physical activities ≥ 4 times/week: 45.05%) [30]. There is no denying that physical activities such as doing exercises and playing sports play an important role in helping people to lose weight and keep fit, thereby improving people's health. Children in Thanhhoa city should spend more time doing these beneficial activities.

Strengths and limitations

This is the first study conducted to investigate the prevalence and factors associated with overweight and obesity among primary school children in Thanhhoa province. In this study, only p-values less than 0.001 were considered statistically significant by reason of the growing problems involving the reproducibility crisis in recent years. Besides strengths, this study has some following limitations. Firstly, causal relationships between risk factors and overweight/obesity cannot be determined because this is only a cross-sectional study. Secondly, data were only collected for primary school children aged 6-11 years in urban areas, not including rural areas and other age groups. For factors involving children's dietary habits, we only gather information on the frequency (such as rarely, sometimes, and usually). Further studies should focus on collecting data on the total intakes of various kinds of foods that are strongly associated with overweight/obesity (the portion size). Some factors such as child's birth weight and parental BMIs which may be strongly associated with

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children's overweight and obesity were not collected. Last but not least, using a self-administrated questionnaire to collect data can bring about some biases such as recall bias.

Conclusion

One in every three primary school children in Thanhhoa city were either overweight or obese. Besides gender - the significantly associated factor, other potential factors which may be associated with childhood overweight/obesity included mode of transport to school, the people living with the child, mother's occupation, father's education, eating confectionery, the total time of playing sports, and sedentary activities. Parents, teachers, and policymakers can implement interventions in the abovementioned factors to reduce the rate of childhood obesity. In forthcoming years, longitudinal studies should be conducted to determine the causal relationships between potential factors and childhood overweight/obesity.

Contributors

Le GB: Conceptualization, Methodology, Investigation, Software, Data curation, Project administration, Writing – Review & Editing. **Dinh DX:** Methodology, Investigation, Software, Formal analysis, Data curation, Visualization, Supervision, Project administration, Validation, Writing – Original Draft Preparation, Writing – Review & Editing.

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Competing interests

None declared.

Ethics statements

Ethics approval

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The study proposal was approved by the ethics committee of the University of Medicine and Pharmacy at Ho Chi Minh City (number 914/HĐĐĐ-ĐHYD).

Patient consent for publication

Written informed consent was obtained from the parents of all primary school students participating in this research.

Provenance and peer review

Not commissioned; externally peer-reviewed.

Data availability statement

Data are available upon reasonable request. Please contact the corresponding author (dinhxuandai.224@gmail.com) if you are interested in accessing data from our research.

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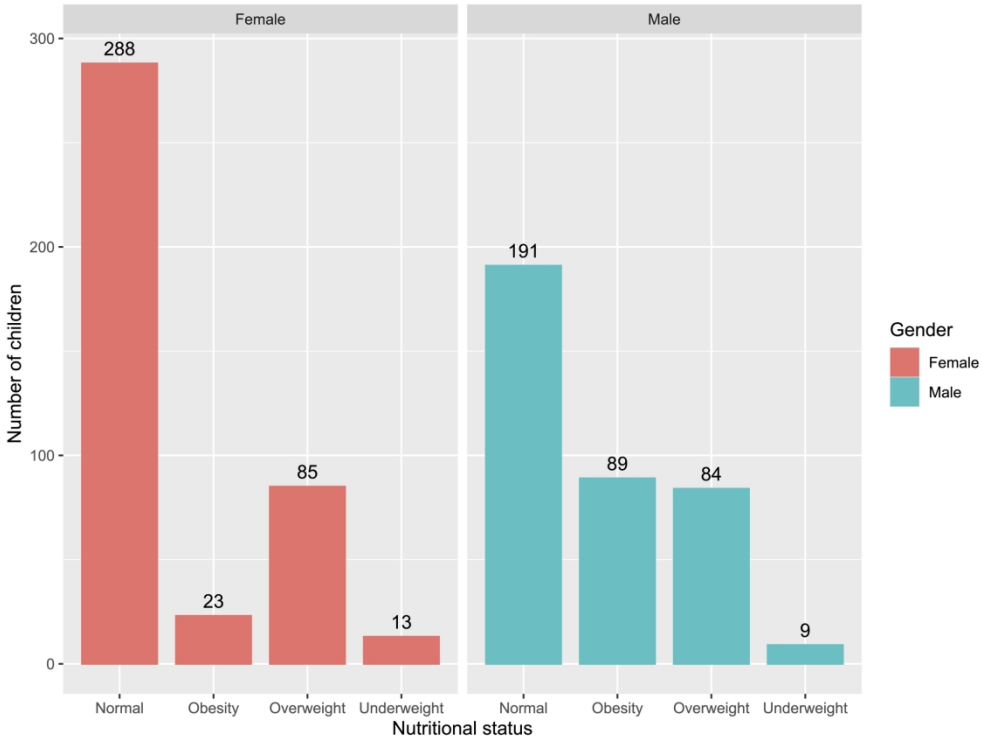

Figure 1. The nutritional status of children classified by gender

190x143mm (300 x 300 DPI)

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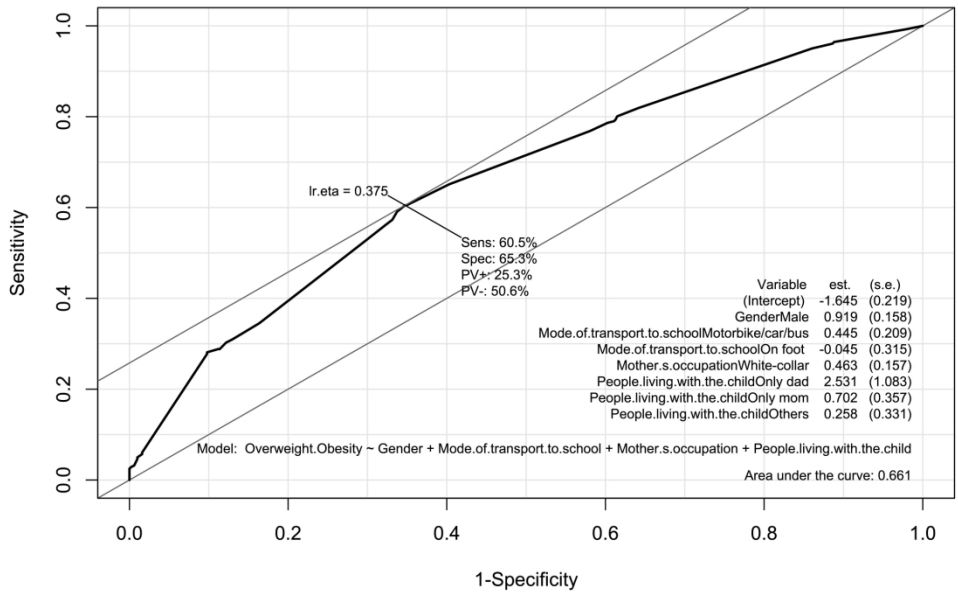

Figure 2. The receiver operating characteristic (ROC) curve analysis for the multivariate logistic regression model

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THE SUMMARY QUESTIONNAIRE

Determining the prevalence and factors associated with overweight and obesity among children in Thanhhoa city, Vietnam

For children and their parents

A. CHILDREN AND PARENTS' INFORMATION

No	Question	Answer
1	Child's birthday (day/month/year)	..... / ..... / .....
2	The number of children in your family	
3	Father's education	☐ Under secondary ☐ Secondary ☐ High school ☐ University ☐ Post-university
4	Father's occupation	☐ Farmer ☐ Worker ☐ Trader ☐ Government worker ☐ Others: .....
5	Mother's education	☐ Under secondary ☐ Secondary ☐ High school ☐ University ☐ Post-university

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6	Mother's occupation	☐ Farmer ☐ Household ☐ Worker ☐ Trader ☐ Government worker ☐ Others: .....
7	Family income (per month)	..... Vietnam dongs
8	People living with the child	☐ Both father and mother ☐ Only mother ☐ Only father ☐ Others: .....
9	Mode of transport to school	☐ On foot/Walking ☐ Bicycle ☐ Motorbike/car/bus

B. Children's dietary habits

Note: Rarely: 1-3 days/month or 1 day/week,

Sometimes: 2 - 4 days/week, Usually: 5 - 6 days/week

No	Dietary habits	Answer
1	Eating breakfast	☐ Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Every day

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No	Dietary habits	Answer
2	Eating lunch	☐ Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Every day
3	Eating dinner	☐ Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Every day
4	Eating after 20:00	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
5	Eating vegetables	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
6	Eating fast food	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
7	Eating confectionery, sweet foods	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day

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No	Dietary habits	Answer
8	Drinking soda, soft drinks	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day

C. Children's physical and sedentary activities

No	Activities	Answer
	Physical activities	
1	Playing sports	☐ Yes ☐ No
1.1	Football	..... times/week x ..... minutes/time
1.2	Skipping	..... times/week x ..... minutes/time
1.3	Shuttlecock kicking	..... times/week x ..... minutes/time
1.4	Running/jogging	..... times/week x ..... minutes/time
1.5	Badminton	..... times/week x ..... minutes/time
1.6	Martial arts	..... times/week x ..... minutes/time
1.7	Other sports:	 ..... times/week x ..... minutes/time ..... times/week x ..... minutes/time ..... times/week x ..... minutes/time
2	Playing place	☐ Indoor (shade) ☐ Outdoor (sunlight)
3	Doing household chores	☐ Yes ☐ No
	Sedentary activities	
4.1	Watching television	..... minutes/day
4.2	Using computers/laptops	..... minutes/day
4.3	Using phones/tablets	..... minutes/day

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4.4	Reading magazines, newspapers, books...	..... minutes/day
4.5	Other activities:	.... minutes/day ..... minutes/day ..... minutes/day

For data collectors (collect data when measuring the height and weight of children)

No	Child's information	Answer
1	Name	
2	Gender	☐ Male ☐ Female
3	Grade	☐ One ☐ Two ☐ Three ☐ Four ☐ Five
4	School's name	
5	School type	☐ Public ☐ Private
6	Area	☐ Urban ☐ Suburb
7	Height	..... meters
8	Weight	..... kilograms

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	7-8
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	7-8
		(*e*) Describe any sensitivity analyses	NA

Continued on next page

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Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9-20
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	NA
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*NA*
		Cross-sectional study—Report numbers of outcome events or summary measures	*7-8*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-23
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-23
Discussion			
Key results	18	Summarise key results with reference to study objectives	24, 28
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	27-28
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	24-28
Generalisability	21	Discuss the generalisability (external validity) of the study results	24-28
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	28

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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BMJ Open

Prevalence and associated factors of overweight and obesity among primary school children: a cross-sectional study in Thanhhoa city, Vietnam

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Secondary Subject Heading:	Paediatrics, Public health, Epidemiology, Nutrition and metabolism
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Title page

Prevalence and associated factors of overweight and obesity among primary school children: a cross-sectional study in Thanhhoa city, Vietnam

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Word count: 3,420 (excluding abstract, figures, tables, and references)

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Abstract

Objective: To determine the prevalence and associated factors of overweight and obesity among primary school children (6 to 11 years old) in Thanhhoa city in 2021.

Design: Cross-sectional study.

Setting: Seven primary schools in Thanhhoa city, Vietnam.

Participants: 782 children (and their parents).

Primary and secondary outcome measures: Two-stage cluster random sampling was used for selecting children and data were collected from January to February 2021. A self-administrated questionnaire was designed for children and their parents. Children's height and weight were measured and BMI-for-age z-scores were computed using the WHO Anthro software version 1.0.4. Data were analysed using R software version 4.1.2. The associations between potential factors and childhood overweight/obesity were analysed through univariate and multivariate logistic regression analyses. Variables were selected using the Bayesian Model Averaging method.

Results: The prevalence of overweight/obesity among primary school children in Thanhhoa city was 35.93% (overweight 21.61% and obesity 14.32%). The proportion of overweight girls was nearly equal to that of boys (20.78% and 22.52%, respectively, p=0.6152) while the proportion of boys with obesity was four times as many as that of girls (23.86% and 5.62%, respectively, p<0.0001). Child's sex was the factor significantly associated with childhood overweight/obesity. Boys had double the risk of being overweight/obese than girls (adjusted odds ratio: aOR=2.51, p<0.0001). Other potential factors which may be associated with childhood overweight/obesity included mode of transport to school, the people living with the child, mother's occupation, father's education, eating confectionery, the total time of doing sports, and sedentary activities.

Conclusion: One in every three primary school children in Thanhhoa city were either overweight or obese. Parents, teachers, and policymakers can implement interventions in the aforementioned factors to reduce the rate of childhood obesity. In forthcoming years, longitudinal studies should be

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conducted to determine the causal relationships between potential factors and childhood overweight/obesity.

Keywords: associated factors, primary school children, obesity, overweight, Thanhhoa city, Vietnam.

Strengths and limitations of this study

- Variables in the multivariate logistic regression model were selected using the Bayesian Model Averaging method.
- By reason of the growing problems involving the low reproducibility probability in recent years, a factor was only regarded as a statistically significant variable if its p-value was lower than 0.001.
- Causal relationships between factors and overweight/obesity cannot be determined because this is only a cross-sectional study.
- Using a self-administrated questionnaire can also bring about some biases such as recall bias.
- The area under the curve of the multivariate logistic regression model is not high, this model cannot be widely used to prognosticate obesity/overweight status in children.

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Background

As per the World Health Organization (WHO), "overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health" [1]. In 2017, overweight and obesity were the rationales behind the deaths of more than 4 million people. From 1975 to 2016, the prevalence of overweight/obesity among children and adolescents aged 5-19 years rocketed from 4% to 18% [2]. In 2016, globally, there were approximately 340 million overweight/obese children and adolescents aged 5-19 years [1]. In the United States, there was a significant increase in the prevalence of children with overweight and class III obesity from 1999 to 2016 [3]. It is estimated that roughly 33% of children aged 6-11 years and 50% of adolescents aged 12-19 years will become overweight or obese in 2030 [4]. In almost all European countries, from 1999 to 2016, the prevalence of overweight/obesity among children aged 2-13 years was very high, especially in some Mediterranean countries. About 25% of obese children were severely obese [5, 6]. In Vietnam, the prevalence of overweight/obesity among children and adolescents aged 5-19 years soared from 8.5% in 2010 to 19.0% in 2020 [7]. Data from other countries (such as Spain [8], China [9-12], Greece [13], Poland [14], and Australia [15]) also showed the high prevalence of overweight and obesity among children and adolescents. Generally, obesity in childhood is a worldwide epidemic requiring urgent actions and practical interventions.

From 2010 to now, globally, there has been a multitude of studies conducted to determine the prevalence and factors associated with overweight/obesity among children and adolescents [16-44]. The first group of risk factors significantly associated with overweight/obesity among children is the characteristics of children and their families, including child's sex [17-22], child's age [18, 19, 21], birth order [19], overweight at birth [19], the number of siblings [19, 23], school type (public/private) [18, 25], father/mother's education [18, 26, 27], father/mother's occupation [17, 19, 24], parental overweight/obesity or BMIs [18, 19, 24, 29, 30], and residence (urban/rural) [21, 22, 24]. The second group is the dietary habits of children, such as food intake [29], dinner time [26], fast food, sweets, sugary/sweetened drinks [17, 22, 25, 31], and eating vegetables/fruits [29, 32]. Other factors include

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physical activities (exercises/playing sports) [20, 29], mode of transport to school [17, 26], and sedentary activities (watching television, computer game playing, sleeping) [17, 19, 29, 31, 32].

In Vietnam, only two previous studies were conducted in Haiphong city, Vietnam to measure the prevalence of overweight/obesity among primary school children [33, 34]. Thanhhoa is a province located in the central part of Vietnam. Up to now, there is no study conducted in this province to determine associated factors and the prevalence of overweight/obesity among children. This research was conducted to determine the prevalence and associated factors of childhood overweight/obesity among primary school children in Thanhhoa city in 2021. We hypothesized that the characteristics of children and their parents, children's dietary habits, physical activities, and sedentary activities are risk factors associated with overweight/obesity among children in Thanhhoa city.

Methods

This cross-sectional, questionnaire-based survey was carried out in Thanhhoa city, Vietnam from Jan 01 to Feb 28, 2021. This city was chosen for study by reason of the following rationales. Firstly, the first author is living in Thanhhoa city. By virtue of the outbreak of the COVID-19 pandemic, conducting a survey in this place facilitated the data-collection process. In addition, during the time for data collection, Thanhhoa city was devoid of COVID-19 patients and therefore, travel restrictions and social distancing were not applied in this city. Last but not least, the data-collection process was also much easier thanks to the close relationship between authors and leaders of the education industry in Thanhhoa.

Patient and public involvement

No patient involved.

Sample

The study population was primary school children in Thanhhoa city (grade one to five). There are 48 primary schools and about 35,000 primary school students in this city. Seven schools were randomly selected for investigation. Data were collected with the approval of the headmasters/headmistresses of these primary schools. In each school, for each grade, one class was

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randomly selected. All students in these selected classes were recruited in this research, excluding children with amputations or those contracting any chronic/acute health conditions. The sample size was computed using the following formula:

$$n = Z^2_{1-\alpha/2}\frac{p(1-p)}{d^2}\text{Deff}$$

- Deff=1+ICCx(n-1)=1+0.05x(30-1)=2.45 (ICC: interclass correlation for the statistic (ICC=0.05), n=the average size of the clusters (approximately 30 students/class)).

- p=0.221 (from a study conducted in Haiphong city in 2018 [34])

- Z=1.96 (α=0.05), d=0.05 (because 0.1<p<0.3)

The minimum sample size was 700 children. To increase this study's validity and generalizability, a total of 986 children were approached. The response rate was 84.69%. However, after checking data-collection forms, 53 children were excluded from this research because of missing values (Questions in the data-collection forms were not fully answered). The final sample size was 782 children, adequate to achieve a margin of error of 5%, a confidence level of 99%, and a response distribution of 50%.

Questionnaire

In the light of numerous difficulties in directly interviewing children, a self-administrated questionnaire was designed for both children and their parents. Based on the questionnaires of previous studies [19, 25, 27, 29-32], questions were selected, amended, and translated into Vietnamese. Furthermore, five senior lecturers of the University of Medicine and Pharmacy at Ho Chi Minh City aided the research team to review the questionnaire. The final questionnaire which can be seen in Supplemental File 1 included three main parts. Part 1 included questions on socio-demographic characteristics of children and parents. Part 2 focused on investigating the dietary habits of children. Part 3 included questions in relation to children's physical and sedentary activities. To validate the questionnaire, a pilot study was conducted with the participation of 20 children and their parents. The total Cronbach's alpha = 0.85 (the dietary habits of children: 0.67, physical and sedentary activities: 0.81).

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Supplemental File 1

Data collection and anthropometric measurements

Each student was given one data-collection form and one written consent form. Students took these two forms, went home, and filled in these forms in company with their parents. Then, the teachers collected forms from their students. A week later, data collectors came back to selected classes and received data-collection forms and written consent forms from teachers.

For students having both forms, their height and weight were measured by data collectors with the aid of the teachers during playtime. Weight and height were measured for children wearing light clothing without shoes. Weight was measured in kilograms (kg) with the Microlife Weight Scale 50A (manufactured in Sweden) and rounded to the nearest 0.1kg. Each child was measured twice and his/her weight was the average weight. If the difference between the two measurements was more than 0.1kg, a third measurement was carried out. Height was also measured twice with a SECA 222 (a stadiometer manufactured in Germany) and recorded in meters (m) with an accuracy of 0.01m. The WHO Anthro software version 1.0.4 was employed for anthropometric calculation. BAZs (BMI-for-age z-scores) were used to categorized children into groups: thin, normal, overweight, and obese. A child was categorized as thin, overweight, and obese if BAZ<-2SD, 2SD>BAZ>1SD, and BAZ≥2SD, respectively.

Data analysis

Data were analyzed using R software version 4.1.2. The correlations between factors (independent variables) and nutritional status of children were analyzed using the Chi-squared test and Fisher's exact test (when at least one expected value was less than 5). All variables with p-values<0.2 were included in the univariate logistic regression analyses. Variables in the multivariate logistic regression model were selected using the Bayesian Model Averaging method. This model was used to adjust for confounding and explore the associations between factors (independent variables) and the nutritional status of children (dependent variable - a binary variable indicating whether or not children were overweight/obese). The goodness of fit of the multivariate logistic

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model was assessed using the Hosmer–Lemeshow test and the value of area under the curve (AUC). By reason of the growing problems involving low reproducibility probability in recent years, in this study, a factor was only regarded as a statistically significant variable if its p-value<0.001.

Results

The average age of children was 8.42 ± 1.36 years old. More than 71% of children came from public schools. Most of the children lived with both parents (88.87%) and another sibling (73.02%). The parental education levels were primarily high school and university (father: 77.36%, mother: 79.15%). The monthly income of most families was lower than 20 million Vietnam dongs (76.22%). Factors associated with childhood overweight/obesity included child's sex (p<0.0001), the number of children in the family (p=0.0146), father's education (p=0.0390), father's occupation (p=0.0693), mother's education (p=0.0851), mother's occupation (p=0.0017), the people living with the child (p=0.0021), and family income (p=0.0011) (Table 1, Supplemental File 2).

Table 1. Demographic and socio-economic characteristics of children and their parents

No	Characteristics		Summary statistics*
1	Child's sex	Male	373 (47.70)
		Female	409 (52.30)
2	Child's age** (months)		101.02 ± 16.33 (72 - 131)
3	Grade	One	145 (18.54)
		Two	159 (20.33)
		Three	177 (22.63)
		Four	170 (21.74)
		Five	131 (16.75)
4	Area (school location)	Urban	562 (71.87)
		Suburb	220 (28.13)
5	School type	Public	557 (71.23)

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No	Characteristics		Summary statistics*
		Private	225 (28.77)
6	The number of children in the family (including the child in this study)		2.15 ± 0.62 (1 - 5)
7	Father's education	Under secondary	23 (2.94)
		Secondary	74 (9.46)
		High school	238 (30.43)
		University	367 (46.93)
		Post-university	80 (10.23)
8	Father's occupation	Blue-collar worker	515 (65.86)
		White-collar worker	267 (34.14)
9	Mother's education	Under secondary	18 (2.30)
		Secondary	81 (10.36)
		High school	215 (27.49)
		University	404 (51.66)
		Post-university	64 (8.18)
10	Mother's occupation	Blue-collar worker	438 (56.01)
		White-collar worker	344 (43.99)
11	People living with the child	Mother and father	695 (88.87)
		Only father	9 (1.15)
		Only mother	36 (4.60)
		Others (grandparents...)	42 (5.37)
12	Family income per month in 2020 (million Vietnam dongs)		13.75 ± 11.95 (2 - 120)

*: mean±SD (minimum-maximum) for continuous variables, number (%) for categorical variables

**: child's age = (2020 - child's birth year) x 12 + (12 - child's birth month)

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No	Characteristics	Summary statistics*
Exchange rate: 1 million Vietnam dongs = 42.828US$ Occupation: Blue-collar workers (people who do work needing strength or physical skill rather than office work, for example, farmers, drivers, traders). White-collar workers (people who work in offices, doing work needings mental rather than physical effort, for example, doctors, teachers).		

Supplemental File 2

Children's dietary habits

Most of the children had breakfast, lunch, and dinner daily. Only 44 children (5.63%) usually had a meal after 20:00. About three-fifths of children ate vegetables every day/almost every day. The proportions of children usually eating confectionery and fast food were low (13.81% and 2.69%, respectively). Only 26 children (3.32%) drank soda/soft drinks more than five days per week. Among factors related to dietary habits of children, eating confectionery can be a potential factor associated with childhood overweight/obesity (p=0.0172) (Fig 1, Supplemental File 2).

Figure 1. Dietary characteristics of children. Rarely: 1-3 days/month or one day/week, Sometimes: 2-4 days/week, Usually: 5-6 days/week.

Children's physical and sedentary activities

Most of the children assisted their parents in doing household chores (86.57%). More than 37% of children did not play sports. Two-fifths of children played sports from one to four times per week. The average time of doing sports among children was 1.50 ± 2.28 hours per week. Only 231 children (29.54%) went to school by themselves (walking: 9.97%, cycling: 19.57%). For sedentary activities, the proportion of children using computers/laptops for recreational activities was extremely low. The number of children watching television and using phones/tablets more than 3 hours per day was negligible. Only 62 children (7.92%) read books, newspapers, or magazines more than an hour per day. In general, the total time for sedentary activities of almost all children was lower than two hours per day (Table 2).

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Table 2. Physical and sedentary activities of children

No	Children's activities		n (%)
1	**Physical activities**		
1.1	**Type of sports**	Football	191 (24.42)
		Skipping	115 (14.71)
		Badminton	112 (14.32)
		Running/jogging	107 (13.68)
		Marterial arts	40 (5.12)
		Cycling	36 (4.60)
		Shuttlecock kicking	21 (2.69)
		Basketball	18 (2.30)
		Other sports (Swimming...)	32 (4.09)
1.2	**The number of times playing sports per week**	Not playing sports	291 (37.21)
		1 to 2 times	187 (23.91)
		3 to 4 times	146 (18.67)
		5 to 6 times	69 (8.82)
		7 times or more	89 (11.38)
1.3	**The total time of playing sports per week**	Not playing sports	291 (37.21)
		Less than 1h	102 (13.04)
		1h - less than 2h	172 (21.99)
		2h - less than 3h	87 (11.13)
		3h - less than 4h	48 (6.14)
		4h or more	82 (10.49)
1.4	**Doing household chores**	Yes	677 (86.57)
		No	105 (13.43)

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No	Children's activities		n (%)
1.5	**Mode of transport to school**	On foot	78 (9.97)
		Bicycle	153 (19.57)
		Motorbike/car/bus	551 (70.46)
2	**Sedentary activities**		
2.1	**Watching television**	Never	168 (21.48)
		Less than 1h/day	402 (51.41)
		From 1h to 3h/day	210 (26.85)
		More than 3h/day	2 (0.26)
2.2	**Using computers, laptops**	Never	687 (87.85)
		Less than 1h/day	78 (9.97)
		From 1h to 3h/day	16 (2.05)
		More than 3h/day	1 (0.13)
2.3	**Using phones, tablets**	Never	451 (57.67)
		Less than 1h/day	264 (33.76)
		From 1h to 3h/day	66 (8.44)
		More than 3h/day	1 (0.13)
2.4	**Reading books, newspapers, magazines**	Never	400 (51.15)
		Less than 1h/day	320 (40.92)
		From 1h to 3h/day	59 (7.54)
		More than 3h/day	3 (0.38)
2.5	**The total time of sedentary activities**	Less than 1h/day	314 (40.15)
		From 1h to 2h/day	398 (50.90)
		More than 2h/day	70 (8.95)

h: hour

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The nutritional status of children

The proportion of overweight girls (20.78%) was nearly equal to that of boys (22.52%) (p=0.6152). However, the proportion of boys with obesity (23.86%) was four times as many as that of girls (5.62%) (p<0.0001). Overall, the prevalence of overweight/obesity among primary school children in Thanhhoa city was 35.93% (overweight 21.61% and obesity 14.32%) (Fig 2).

Figure 2. The nutritional status of children classified by child's sex

Factors associated with overweight and obesity among primary school children

The results from the univariate logistic regression model show that childhood overweight/obesity can be associated with child's sex (p<0.0001), using motorbike/car/bus to go to school (p=0.017), children living with only dad (p=0.0102), fathers with under secondary education level (p=0.030), mother's occupation (p=0.0014), usually eating confectionery (p=0.0092), the total time of doing sports per week (p=0.0076), and the total time for sedentary activities per day (p=0.0348). The results from the multivariate logistic model show that sex, mode of transport to school, people living with the child, and mother's occupation were several factors associated with childhood overweight/obesity. Child's sex was the factor significantly associated with childhood overweight/obesity with p<0.0001. Hosmer-Lemeshow goodness of fit test for the multivariate logistic regression model showed that this model can adequately fit the data (X-squared=2.107, df=8, p=0.9776). The area under the curve (AUC) of the multivariate logistic regression model was 0.6525 (95%CI: 0.6127-0.6924) (Table 3 and Fig 3).

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Table 3. Factors associated with overweight and obesity among primary school children in Thanhhoa city

No	Factor	Univariate logistic regression		Multivariate logistic regression	
		OR (95% CI)	p-value	aOR (95% CI)	p-value
1	**Child's sex** (reference: Female)				
	Male	2.41 (1.79, 3.26)	< 0.0001	2.48 (1.83, 3.38)	< 0.0001
2	**School** (reference: Private)				
	Public	0.76 (0.55, 1.05)	0.0952		
3	**The number of children in the family** (continuous variable)				
	Per children	0.80 (0.62, 1.01)	0.0694		
4	**Mode of transport to school** (reference: Bicycle)				
	On foot	1.21 (0.66, 2.17)	0.534		
	Motorbike/car/bus	1.61 (1.10, 2.40)	0.017	1.58 (1.12, 2.23)	0.0096
5	**People living with the child** (reference: Both mother and father)				
	Only father	15.36 (2.80, 285.83)	0.0102	11.96 (2.07, 226.84)	0.0219
	Only mother	1.72 (0.87, 3.37)	0.1149		
	Others (grandparents...)	1.44 (0.76, 2.70)	0.2572		
6	**Father's education** (reference: High school)				
	Under secondary	0.20 (0.03, 0.69)	0.030		
	Secondary	1.32 (0.77, 2.26)	0.311		
	University	1.29 (0.92, 1.83)	0.140		
	Post university	1.23 (0.72, 2.08)	0.440		
7	**Father's occupation** (reference: Blue-collar worker)				
	White-collar worker	1.34 (0.99, 1.82)	0.0584		

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No	Factor	Univariate logistic regression		Multivariate logistic regression	
		OR (95% CI)	**p-value**	**aOR (95% CI)**	**p-value**
8	**Mother's occupation** (reference: Blue-collar worker)				
	White-collar worker	1.62 (1.21, 2.17)	0.0014	1.56 (1.15, 2.12)	0.0040
9	**Mother's education** (reference: High school)				
	Under secondary	0.25 (0.04, 0.92)	0.0724		
	Secondary	0.96 (0.55, 1.64)	0.8799		
	University	1.32 (0.93, 1.87)	0.1210		
	Post university	1.14 (0.63, 2.03)	0.6651		
10	**Family income** (continuous variable)				
	Per one million Vietnam dongs	1.01 (1.00, 1.02)	0.0563		
11	**Eating confectionery/sweet foods** (reference: Never/Rarely)				
	Sometimes	0.62 (0.42, 0.91)	0.0158		
	Usually/Every day	0.49 (0.28, 0.83)	0.0092		
12	**The time of doing sports per week** (continuous variable)				
	Per hour	1.09 (1.02, 1.16)	0.0076		
13	**The time for sedentary activities per day** (continuous variable)				
	Per hour	1.19 (1.01, 1.41)	0.0348		

The multivariate logistic regression model was chosen using the Bayesian Model Averaging method. Analysing the relation between two categorical variables was done using Cramer's V. V-values were lower than 0.08 for all pairs of variables in the multivariate logistic regression model. Multicollinearity did not occur in this model.

aOR: adjusted odds ratio, CI: confidence interval

Exchange rate: 1 million Vietnam dongs = 42.828US$

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Figure 3. The receiver operating characteristic (ROC) curve analysis for the multivariate logistic regression model

Discussion

This is the first study conducted in Thanhhoa city to determine the prevalence and risk factors associated with overweight/obesity among primary school children. The results show that among 782 investigated children, 281 children (35.93%) were overweight/obese, congruent with the results of several studies conducted in urban areas/cities in Port Said (2011): 31.2% [35]; Uberaba, Brazil (2012-2013): 32.3% [36]; Ankara, Turkey (2015): 35.9% [27]; and New Zealand (2017-2018): 31.9% [37]. The prevalence of overweight/obesity among primary school children in Thanhhoa is lower than the results of Hochiminh city, Vietnam (2014-2015): 55.6% [38] but far higher than the results of Rikuzentakata, Japan (2013): 7.8% [39]; Guangzhou, China (2014): 18.2% [18]; Chocó, Colombia (2015): 13.2% [40]; Lomé, Togo (2015): 7.1% [32]; Nepal (2017): 25.7% [17]; and Abidjan, Ivory Coast (2018): 10.2% [41]. Therefore, the epidemic of overweight/obesity among primary school children can be regarded as a matter of concern in Thanhhoa city.

Child's sex was the risk factor significantly associated with overweight/obesity among children in Thanhhoa. The odds of being overweight/obese among boys was 2.51 times more likely when compared to girls ($p<0.0001$), in line with the results from studies conducted in urban Nepal [17], Montenegro [19], China [11, 18], and Iran [42]. By contrast, in some other countries, girls were more likely to be overweight/obese than boys, for example in Ethiopia [28] and Ivory Coast [41]. In Brazil, there was no difference in obesity prevalence between boys and girls ($p>0.05$) [43]. There were several possible rationales behind the higher prevalence of overweight/obesity among boys than girls in Thanhhoa city. Firstly, in comparison with girls, the average time (minutes per day) for sedentary activities of boys (73.12) was higher than girls (67.77), including watching television: 37.45 and 32.28, using computers/phones/tablets: 19.65 and 16.79, respectively. This reason was also reported in previous studies in Montenegro [19] and Columbia [45]. In addition, in many countries, male chauvinism is still rife. In Vietnam, many parents hold a belief that girls are less valuable than

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boys and strong fertility desire commonly appears in families without sons [46]. As a result, parents usually cosset their sons more than their daughters. Another possible reason is that boys consumed unhealthy foods (such as fast food) more frequently than girls [47], thereby being able to increase the risk of being overweight/obese. In this study, we only asked children's parents about the frequency of consuming fast food, confectionery, and soda. Future studies should focus on the total intakes of these unhealthy foods to assess their effects on children's nutritional status more specifically.

Besides sex, three other risk factors which could be associated with childhood overweight/obesity included transportation to school, the mother's occupation, and the people living with the child. In Nepal, the mother's occupation was also the risk factor significantly associated with childhood overweight/obesity ($p<0.001$) [17]. Regarding transportation to school, the percentage of children who walked/cycled to school in Thanhhoa (29.54%) was far lower than the result of Lomé, Togo (90.1%) [32] and Port Said city (47.3%) [35]. In Thanhhoa, children going to school with the aid of parents/other adults had more risks of being overweight/obese than those going to school by themselves, in line with the result of a study in Nepal [17]. For the factor involving people living with the child, 88.87% of children in Thanhhoa lived with both parents, similar to the result of Montenegro (91.11%) [19]. By virtue of the low divorce rate, the number of children living with only a father/mother was extremely low (9 and 36 cases, respectively). This can affect the accuracy and the reproducibility of results involving this factor. It is necessary to carry out other studies to re-analyze the effect of this factor on the prevalence of being overweight/obese among children.

Besides the four abovementioned factors, the results from univariate logistic regression show that father's education, confectionery consumption, the time of doing sports, and the time for sedentary activities can be risk factors associated with overweight/obesity among children in Thanhhoa city. In Hanoi, Vietnam, the father's education may be a factor associated with the prevalence of overweight/obesity among children ($p=0.05$) [29]. For sugary/sweetened foods, the proportion of children eating confectionery more than five times/week in Thanhhoa was 13.81%, in line with the result of Nepal (16.9%) [17] but lower than the result of Sharjah, UAE (54.6%) [31]. In

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lieu of overweight/obese children having a higher consumption of confectionery, our results showed a reverse association. In comparison with children never/rarely eating confectionery, the odds of being overweight/obese were respectively 38% and 51% lower than that of children sometimes and usually/every day eating confectionery, in line with the result of a systematic review and meta-analysis [48]. Although eating chocolate and sugar candies may not have pernicious effects on children's health [49], excessive consumption of these types of foods is unnecessary and detrimental in some cases.

Regarding sedentary activities, in Thanhhoa, the odds ratio for being overweight/obese increased 19% for a one-hour increase in the total time of sedentary activities (p=0.0348). In Nepal, sedentary activities were the factor significantly associated with overweight/obesity among children: children spending > 2 hours a day on weekends on sedentary activities were three times more likely to be overweight/obese than those spending ≤ 2 hours a day on weekends [17]. Several previous studies having the same results include Lomé, Togo [32] and Montenegro [19]. For physical activities, playing sports was not the predilection of many primary school children in Thanhhoa. Only 25.58% of children played sports more than three times/week, far lower than the result of China (physical activities ≥ 4 times/week: 45.05%) [30]. There is no denying that physical activities such as doing exercises and playing sports play an important role in helping people to lose weight and keep fit, thereby improving people's health. Children in Thanhhoa city should spend more time doing these beneficial activities.

Our results showed that overweight/obesity should be a problematic matter of concern by virtue of the high prevalence of overweight/obesity among primary school children in Thanhhoa city. By reason of the fairly low AUC, the multivariate logistic regression model cannot be widely used to prognosticate obesity/overweight status in children. However, parents, teachers, and policymakers can implement interventions in factors (such as eating confectionery, playing sports, and sedentary activities) to reduce the rate of childhood obesity. Sports and sedentary activities were associated with dietary patterns and the quality of food choices which can help prevent childhood obesity [50].

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Strengths and limitations

This is the first study conducted to investigate the prevalence and factors associated with overweight and obesity among primary school children in Thanhhoa province. In this study, only p-values less than 0.001 were considered statistically significant by reason of the growing problems involving the low reproducibility probability in recent years. Variables in the multivariate logistic regression model were selected using the Bayesian Model Averaging method.

Besides the aforementioned strengths, this study has some following limitations. Firstly, causal relationships between risk factors and overweight/obesity cannot be determined because this is only a cross-sectional study. Secondly, using a self-administrated questionnaire to collect data can bring about some biases such as recall bias. For factors involving children's dietary habits, we only gather information on the frequency of the meals. Further studies should focus on collecting data on the total intake of various kinds of foods that are strongly associated with overweight/obesity (the portion size). Some factors such as child's birth weight and parental BMIs which may be strongly associated with children's overweight and obesity were not collected. Thirdly, the height of children should be measured in centimeters with an accuracy of 0.1cm, instead of meters with an accuracy of 0.01m. Last but not least, the AUC of the multivariate logistic regression model is not high, this model cannot be widely used to predict obesity/overweight status in children.

Conclusion

One in every three primary school children in Thanhhoa city were either overweight or obese. Besides sex - the significantly associated factor, other potential factors which may be associated with childhood overweight/obesity included mode of transport to school, the people living with the child, mother's occupation, father's education, eating confectionery, the time of playing sports, and sedentary activities. Parents, teachers, and policymakers can implement interventions in these factors to reduce the rate of childhood obesity. In forthcoming years, longitudinal studies should be conducted to determine the causal relationships between potential factors and childhood overweight/obesity.

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Contributors

Le GB: Conceptualization, Methodology, Investigation, Software, Data curation, Project administration, Writing – Review & Editing. **Dinh DX:** Methodology, Investigation, Software, Formal analysis, Data curation, Visualization, Supervision, Project administration, Validation, Writing – Original Draft Preparation, Writing – Review & Editing.

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Competing interests

None declared.

Ethics statements

Ethics approval

The study proposal was approved by the ethics committee of the University of Medicine and Pharmacy at Ho Chi Minh City (number 914/HĐĐĐ-ĐHYD).

Patient consent for publication

Written informed consent was obtained from the parents of all primary school students participating in this research.

Provenance and peer review

Not commissioned; externally peer-reviewed.

Data availability statement

Data are available upon reasonable request. Please contact the corresponding author (dinhxuandai.224@gmail.com) if you are interested in accessing data from our research.

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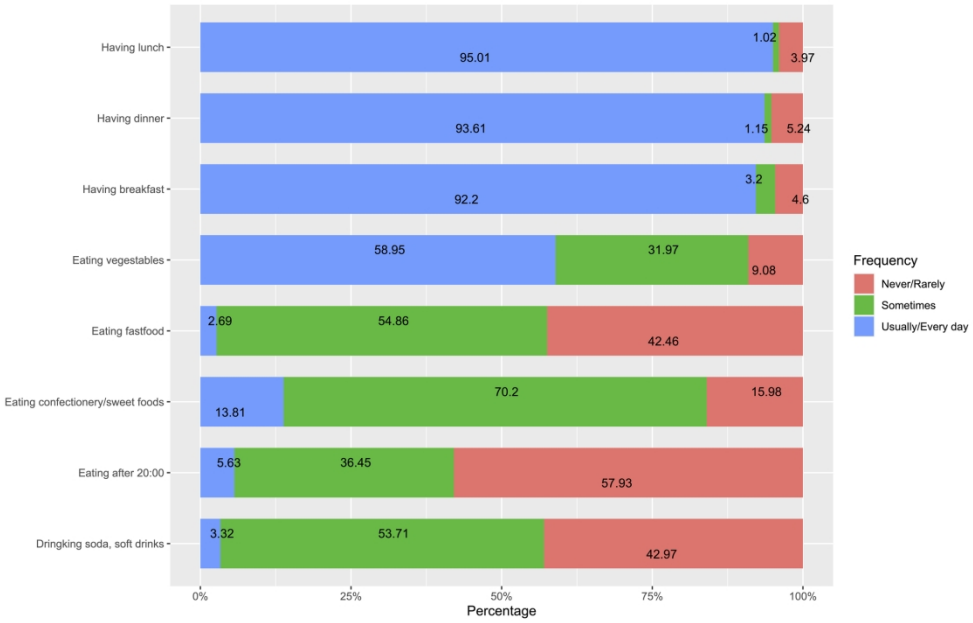

Dietary characteristics of children. Rarely: 1-3 days/month or one day/week, Sometimes: 2-4 days/week, Usually: 5-6 days/week.

190x119mm (300 x 300 DPI)

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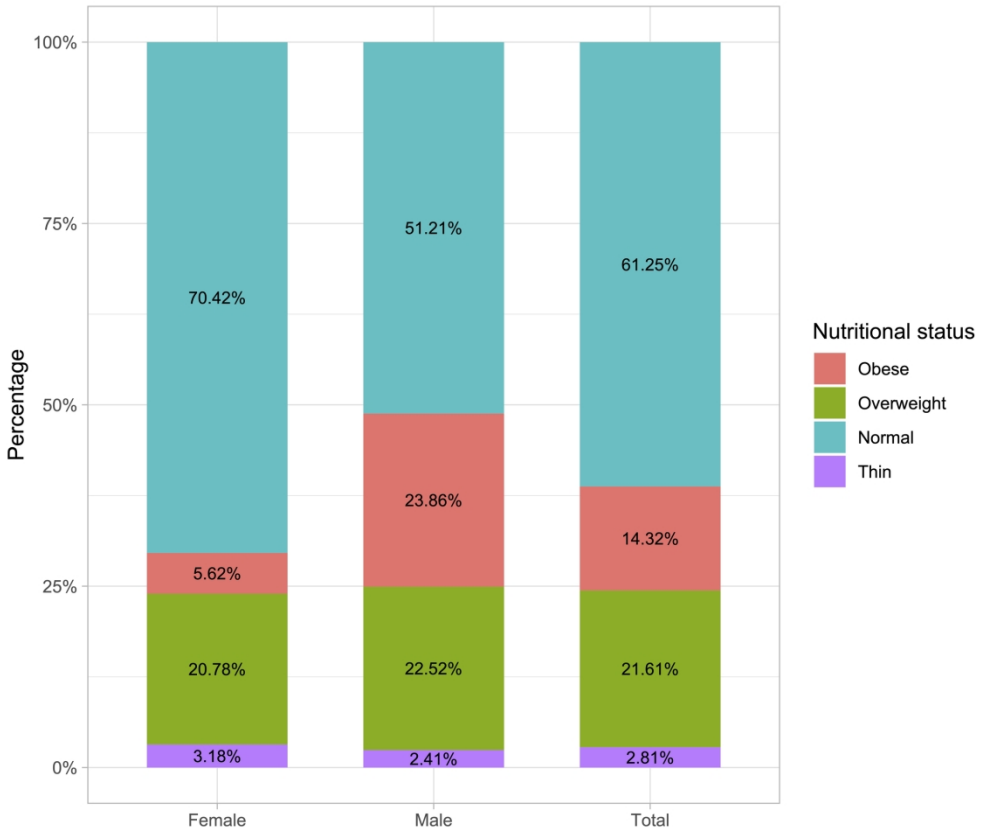

The nutritional status of children classified by child's sex

190x165mm (300 x 300 DPI)

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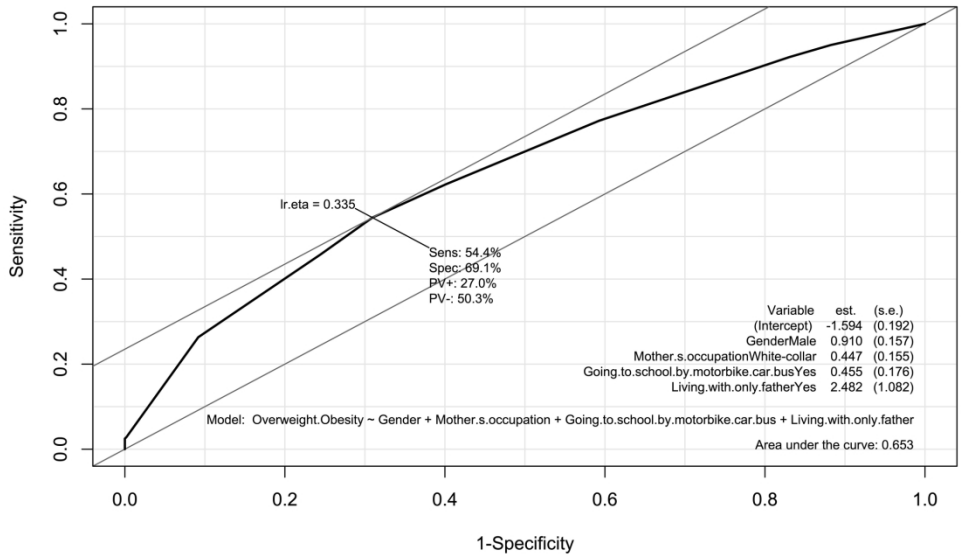

The receiver operating characteristic (ROC) curve analysis for the multivariate logistic regression model

190x125mm (300 x 300 DPI)

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THE SUMMARY QUESTIONNAIRE: Determining the prevalence and factors associated with overweight and obesity among children in Thanhhoa city, Vietnam

For children and their parents

A. Children and parents' information

No	Question	Answer
1	Child's birthday (day/month/year)	..... / ..... / .....
2	The number of children in your family (including the child in this study)	
3	Father's education	☐ Under secondary ☐ Secondary ☐ High school ☐ University ☐ Post-university
4	Father's occupation	☐ Farmer ☐ Worker ☐ Trader ☐ Government worker ☐ Others: .....
5	Mother's education	☐ Under secondary ☐ Secondary ☐ High school ☐ University ☐ Post-university
6	Mother's occupation	☐ Farmer ☐ Household ☐ Worker ☐ Trader ☐ Government worker ☐ Others: .....
7	Family income (per month in 2020)	..... million Vietnam dongs
8	People living with the child	☐ Both father and mother ☐ Only mother ☐ Only father ☐ Others: .....

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B. Children's dietary habits

Note: Rarely: 1-3 days/month or 1 day/week,

Sometimes: 2 - 4 days/week, Usually: 5 - 6 days/week

No	Dietary habits	Answer
1	Eating breakfast	☐ Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Every day
2	Eating lunch	☐ Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Every day
3	Eating dinner	☐ Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Every day
4	Eating after 20:00	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
5	Eating vegetables	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
6	Eating fast food	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
7	Eating confectionery, sweet foods	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
8	Drinking soda, soft drinks	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day

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C. Children's physical and sedentary activities

No	Activities	Answer
	Physical activities	
1	Playing sports	☐ Yes ☐ No
1.1	☐ Football	..... times/week x ..... minutes/time
1.2	☐ Skipping	..... times/week x ..... minutes/time
1.3	☐ Shuttlecock kicking	..... times/week x ..... minutes/time
1.4	☐ Running/jogging	..... times/week x ..... minutes/time
1.5	☐ Badminton	..... times/week x ..... minutes/time
1.6	☐ Martial arts	..... times/week x ..... minutes/time
1.7	Other sports:	 ..... times/week x ..... minutes/time ..... times/week x ..... minutes/time ..... times/week x ..... minutes/time
2	Doing household chores	☐ Yes ☐ No
3	Mode of transport to school	☐ On foot/Walking ☐ Bicycle ☐ Motorbike/car/bus ☐ Others: .....
	Sedentary activities	
4.1	☐ Watching television	..... minutes/day
4.2	☐ Using computers/laptops	..... minutes/day
4.3	☐ Using phones/tablets	..... minutes/day
4.4	☐ Reading magazines, newspapers, books...	..... minutes/day
4.5	Other activities:	 ..... minutes/day ..... minutes/day ..... minutes/day

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For data collectors (collect data when measuring the height and weight of children)

No	Child's information	Answer
1	Name	
2	Gender	☐ Male ☐ Female
3	Grade	☐ One ☐ Two ☐ Three ☐ Four ☐ Five
4	School's name	
5	School type	☐ Public ☐ Private
6	Area (school location)	☐ Urban ☐ Suburb
7	Height	..... meters
8	Weight	..... kilograms

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Supplemental File 2. The association between factors and the nutritional status of children

No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
		Total (782)	**169 (21.61)**	**112 (14.32)**	**281 (35.93)**	**501 (64.07)**	
A	**Demographic and socio-economic characteristics of children and their parents**						
1	Child's sex	Male (373)	84 (10.74)	89 (11.38)	173 (22.12)	200 (25.58)	<0.0001
		Female (409)	85 (10.87)	23 (2.94)	108 (13.81)	301 (38.49)	
2	Child's age (months)	72 to 83 (145)	31 (3.96)	24 (3.07)	55 (7.03)	90 (11.51)	0.2292
		84 to 95 (158)	30 (3.84)	22 (2.81)	52 (6.65)	106 (13.55)	
		96 to 107 (178)	41 (5.24)	34 (4.35)	75 (9.59)	103 (13.17)	
		108 to 119 (170)	35 (4.48)	24 (3.07)	59 (7.54)	111 (14.19)	
		120 to 131 (131)	32 (4.09)	8 (1.02)	40 (5.12)	91 (11.64)	
3	Grade	One (145)	31 (3.96)	24 (3.07)	55 (7.03)	90 (11.51)	0.2045
		Two (159)	30 (3.84)	22 (2.81)	52 (6.65)	107 (13.68	
		Three (177)	41 (5.24)	34 (4.35)	75 (9.59)	102 (13.04)	
		Four (170)	35 (4.48)	24 (3.07)	59 (7.54)	111 (14.19)	
		Five (131)	32 (4.09)	8 (1.02)	40 (5.12)	91 (11.64)	
4	Area (school location)	Urban (562)	121 (15.47)	84 (10.74)	205 (26.21)	357 (45.65)	0.6721
		Suburb (220)	48 (6.14)	28 (3.58)	76 (9.72)	144 (18.41)	
5	School type	Public (557)	119 (15.22)	71 (9.08)	190 (24.30)	367 (46.93)	0.1121
		Private (225)	50 (6.39)	41 (5.24)	91 (11.64)	134 (17.14)	

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No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
6	The number of children in the family (including the child in this study)	1 (62)	17 (2.17)	15 (1.92)	32 (4.09)	30 (3.84)	0.0146*
		2 (571)	118 (15.09)	81 (10.36)	199 (25.45)	372 (47.57)	
		3 (125)	28 (3.58)	13 (1.66)	41 (5.24)	84 (10.74)	
		4 (18)	6 (0.77)	3 (0.38)	9 (1.15)	9 (1.15)	
		5 (6)	0 (0.00)	0 (0.00)	0 (0.00)	6 (0.77)	
7	Father's education	Under secondary (23)	2 (0.26)	0 (0.00)	2 (0.26)	21 (2.69)	0.0390
		Secondary (74)	19 (2.43)	10 (1.28)	29 (3.71)	45 (5.75)	
		High school (238)	48 (6.14)	30 (3.84)	78 (9.97)	160 (20.46)	
		University (367)	83 (10.61)	59 (7.54)	142 (18.16)	225 (28.77)	
		Post-university (80)	17 (2.17)	13 (1.66)	30 (3.84)	50 (6.39)	
8	Father's occupation	Blue-collar worker (515)	107 (13.68)	66 (8.44)	173 (22.12)	342 (43.73)	0.0693
		White-collar worker (267)	62 (7.93)	46 (5.88)	108 (13.81)	159 (20.33)	
9	Mother's education	Under secondary (18)	2 (0.26)	0 (0.00)	2 (0.26)	16 (2.05)	0.0851
		Secondary (81)	18 (2.30)	8 (1.02)	26 (3.32)	55 (7.03)	
		High school (215)	45 (5.75)	26 (3.32)	71 (9.08)	144 (18.41)	
		University (404)	90 (11.51)	69 (8.82)	159 (20.33)	245 (31.33)	
		Post-university (64)	14 (1.79)	9 (1.15)	23 (2.94)	41 (5.24)	
10	Mother's occupation	Blue-collar worker (438)	82 (10.49)	54 (6.91)	136 (17.39)	302 (38.62)	0.0017
		White-collar worker (344)	87 (11.13)	58 (7.42)	145 (18.54)	199 (25.45)	

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No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
11	People living with the child	Mother and father (695)	143 (18.29)	95 (12.15)	238 (30.43)	457 (58.44)	0.0021*
		Only father (9)	4 (0.51)	4 (0.51)	8 (1.02)	1 (0.13)	
		Only mother (36)	11 (1.41)	6 (0.77)	17 (2.17)	19 (2.43)	
		Others (grandparents...) (42)	11 (1.41)	7 (0.90)	18 (2.30)	24 (3.07)	
12	Family income per month in 2020 (million Vietnam dongs)	< 10 (284)	52 (6.65)	29 (3.71)	81 (10.36)	203 (25.96)	0.0011
		10 - 19.99 (312)	70 (8.95)	44 (5.63)	114 (14.58)	198 (25.32)	
		20 - 29.99 (131)	36 (4.60)	27 (3.45)	63 (8.06)	68 (8.70)	
		30 or more (55)	11 (1.41)	12 (1.53)	23 (2.94)	32 (4.09)	
B	**Dietary habits of children** (Rarely: 1-3 days/month or one day/week, Sometimes: 2-4 days/week, Usually: 5-6 days/week)						
1	Breakfast	Never (21)	3 (0.38)	4 (0.51)	7 (0.90)	14 (1.79)	0.9312
		Rarely (15)	4 (0.51)	2 (0.26)	6 (0.77)	9 (1.15)	
		Sometimes (25)	5 (0.64)	4 (0.51)	9 (1.15)	16 (2.05)	
		Usually (28)	6 (0.77)	2 (0.26)	8 (1.02)	20 (2.56)	
		Every day (693)	151 (19.31)	100 (12.79)	251 (32.10)	442 (56.52)	
2	Lunch	Never (20)	5 (0.64)	3 (0.38)	8 (1.02)	12 (1.53)	0.8795*
		Rarely (11)	2 (0.26)	1 (0.13)	3 (0.38)	8 (1.02)	
		Sometimes (8)	1 (0.13)	2 (0.26)	3 (0.38)	5 (0.64)	
		Usually (13)	3 (0.38)	3 (0.38)	6 (0.77)	7 (0.90)	
		Every day (730)	158 (20.20)	103 (13.17)	261 (33.38)	469 (59.97)	

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No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
3	Dinner	Never (30)	5 (0.64)	3 (0.38)	8 (1.02)	22 (2.81)	0.6717*
		Rarely (11)	3 (0.38)	2 (0.26)	5 (0.64)	6 (0.77)	
		Sometimes (9)	1 (0.13)	1 (0.13)	2 (0.26)	7 (0.90)	
		Usually (19)	3 (0.38)	3 (0.38)	6 (0.77)	13 (1.66)	
		Every day (713)	157 (20.08)	103 (13.17)	260 (33.25)	453 (57.93)	
4	Eating after 20:00	Never/Rarely (453)	95 (12.15)	69 (8.82)	164 (20.97)	289 (36.96)	0.334
		Sometimes (285)	62 (7.93)	35 (4.48)	97 (12.41)	188 (24.04)	
		Usually/Every day (44)	12 (1.53)	8 (1.02)	20 (2.56)	24 (3.07)	
5	Eating vegetables	Never/Rarely (71)	17 (2.17)	10 (1.28)	27 (3.45)	44 (5.63)	0.4536
		Sometimes (250)	53 (6.78)	29 (3.71)	82 (10.49)	168 (21.48)	
		Usually/Every day (461)	99 (12.66)	73 (9.34)	172 (21.99)	289 (36.96)	
6	Eating confectionery, sweet foods	Never/Rarely (125)	34 (4.35)	24 (3.07)	58 (7.42)	67 (8.57)	0.0172
		Sometimes (549)	115 (14.71)	76 (9.72)	191 (24.42)	358 (45.78)	
		Usually/Every day (108)	20 (2.56)	12 (1.53)	32 (4.09)	76 (9.72)	
7	Eating fast food	Never/Rarely (332)	70 (8.95)	52 (6.65)	122 (15.60)	210 (26.85)	0.4471
		Sometimes (429)	93 (11.89)	56 (7.16)	149 (19.05)	280 (35.81)	
		Usually/Every day (21)	6 (0.77)	4 (0.51)	10 (1.28)	11 (1.41)	
8	Drinking soda, soft drinks	Never/Rarely (336)	69 (8.82)	57 (7.29)	126 (16.11)	210 (26.85)	0.3225
		Sometimes (420)	97 (12.40)	52 (6.65)	149 (19.05)	271 (34.65)	
		Usually/Every day (26)	3 (0.38)	3 (0.38)	6 (0.77)	20 (2.56)	

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No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
C	**Physical and sedentary activities of children**						
1	Doing household chores	Yes (677)	151 (19.31)	91 (11.64)	242 (30.95)	435 (55.63)	0.8664
		No (105)	18 (2.30)	21 (2.69)	39 (4.99)	66 (8.44)	
2	Playing sports	Yes (491)	114 (14.58)	82 (10.49)	196 (25.06)	295 (37.72)	0.0033
		No (291)	55 (7.03)	30 (3.84)	85 (10.87)	206 (26.34)	
3	The number of times playing sports per week	Not playing sports (291)	55 (7.03)	30 (3.84)	85 (10.87)	206 (26.34)	0.0430
		1 to 2 times (187)	43 (5.50)	36 (4.60)	79 (10.10)	108 (13.81)	
		3 to 4 times (146)	37 (4.73)	20 (2.56)	57 (7.29)	89 (11.38)	
		5 to 6 times (69)	16 (2.05)	10 (1.28)	26 (3.32)	43 (5.50)	
		7 times or more (89)	18 (2.30)	16 (2.05)	34 (4.35)	55 (7.03)	
4	The total time of playing sports per week	Not playing sports (291)	55 (7.03)	30 (3.84)	85 (10.87)	206 (26.34)	0.0050
		Less than 1h (102)	21 (2.69)	20 (2.56)	41 (5.24)	61 (7.80)	
		1h - less than 2h (172)	29 (3.71)	28 (3.58)	57 (7.29)	115 (14.71)	
		2h - less than 3h (87)	32 (4.09)	10 (1.28)	42 (5.37)	45 (5.75)	
		3h - less than 4h (48)	12 (1.53)	6 (0.77)	18 (2.30)	30 (3.84)	
		4h or more (82)	20 (2.56)	18 (2.30)	38 (4.86)	44 (5.63)	
5	Mode of transport to school	On foot (78)	16 (2.05)	9 (1.15)	25 (3.20)	53 (6.78)	0.0416
		Bicycle (153)	26 (3.32)	17 (2.17)	43 (5.50)	110 (14.07)	
		Motorbike/car/bus (551)	127 (16.24)	86 (11.00)	213 (27.24)	338 (43.22)	

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No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
6	Watching television	Never (168)	33 (4.22)	14 (1.79)	47 (6.01)	121 (15.47)	0.0208*
		Less than 1h/day (402)	92 (11.76)	70 (8.95)	162 (20.72)	240 (30.69)	
		From 1h to 3h/day (210)	43 (5.50)	28 (3.58)	71 (9.08)	139 (17.77)	
		More than 3h/day (2)	1 (0.13)	0 (0.00)	1 (0.13)	1 (0.13)	
7	Using computers, laptops	Never (687)	141 (18.03)	99 (12.66)	240 (30.69)	447 (57.16)	0.1486*
		Less than 1h/day (78)	24 (3.07)	11 (1.41)	35 (4.48)	43 (5.50)	
		From 1h to 3h/day (16)	3 (0.38)	2 (0.26)	5 (0.64)	11 (1.41)	
		More than 3h/day (1)	1 (0.13)	0 (0.00)	1 (0.13)	0 (0.00)	
8	Using phones, tablets	Never (451)	94 (12.02)	70 (8.95)	164 (20.97)	287 (36.70)	0.562
		Less than 1h/day (264)	59 (7.54)	36 (4.60)	95 (12.15)	169 (21.61)	
		From 1h to 3h/day (66)	15 (1.92)	6 (0.77)	21 (2.69)	45 (5.75)	
		More than 3h/day (1)	1 (0.13)	0 (0.00)	1 (0.13)	0 (0.00)	
9	Reading books, newspapers, magazines	Never (400)	70 (8.95)	63 (8.06)	133 (17.01)	267 (34.14)	0.0613
		Less than 1h/day (320)	83 (10.61)	40 (5.12)	123 (15.73)	197 (25.19)	
		From 1h to 3h/day (59)	14 (1.79)	8 (1.02)	22 (2.81)	37 (4.73)	
		More than 3h/day (3)	2 (0.26)	1 (0.13)	3 (0.38)	0 (0.00)	
10	The total time of sedentary activities	Less than 1h/day (314)	59 (7.54)	43 (5.50)	102 (13.04)	212 (27.11)	0.1763
		From 1h to 2h/day (398)	85 (10.87)	64 (8.18)	149 (19.05)	249 (31.84)	
		More than 2h/day (70)	25 (3.20)	5 (0.64)	30 (3.84)	40 (5.12)	

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No	Factors (number of children)	The number of children (%)				p-value
		Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
	1. p-values were calculated using the Chi-squared test and Fisher's exact test. *: using Fisher's exact test 2. Occupation: Blue-collar workers (people who do work needing strength or physical skill rather than office work, for example, farmers, drivers, traders). White-collar workers (people who work in offices, doing work needings mental rather than physical effort, for example, doctors, teachers) 3. Exchange rate: 1 million Vietnam dongs = 42.828US$) 4. h: hour					

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	7-8
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	7-8
		(*e*) Describe any sensitivity analyses	NA

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Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	NA
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*NA*
		Cross-sectional study—Report numbers of outcome events or summary measures	*7-8*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-23
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence and associated factors of overweight and obesity among primary school children: a cross-sectional study in Thanhhoa city, Vietnam

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Title page

Prevalence and associated factors of overweight and obesity among primary school children: a cross-sectional study in Thanhhoa city, Vietnam

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Abstract

Objective: To determine the prevalence and associated factors of overweight and obesity among primary school children (6 to 11 years old) in Thanhhoa city in 2021.

Design: Cross-sectional study.

Setting: Seven primary schools in Thanhhoa city, Vietnam.

Participants: 782 children (and their parents).

Primary and secondary outcome measures: Two-stage cluster random sampling was used for selecting children and data were collected from January to February 2021. A self-administrated questionnaire was designed for children and their parents. Children's height and weight were measured and BMI-for-age z-scores were computed using the WHO Anthro software version 1.0.4. Data were analysed using R software version 4.1.2. The associations between potential factors and childhood overweight/obesity were analysed through univariate and multivariate logistic regression analyses. Variables were selected using the Bayesian Model Averaging method.

Results: The prevalence of overweight/obesity among primary school children in Thanhhoa city was 35.93% (overweight 21.61% and obesity 14.32%). The proportion of overweight girls was nearly equal to that of boys (20.78% and 22.52%, respectively, p=0.6152) while the proportion of boys with obesity was four times as many as that of girls (23.86% and 5.62%, respectively, p<0.0001). Child's sex was the factor significantly associated with childhood overweight/obesity. Boys had double the risk of being overweight/obese than girls (adjusted odds ratio: aOR=2.48, p<0.0001). Other potential factors which may be associated with childhood overweight/obesity included mode of transport to school, the people living with the child, mother's occupation, father's education, eating confectionery, the total time of doing sports, and sedentary activities.

Conclusion: One in every three primary school children in Thanhhoa city were either overweight or obese. Parents, teachers, and policymakers can implement interventions in the aforementioned factors to reduce the rate of childhood obesity. In forthcoming years, longitudinal studies should be

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conducted to determine the causal relationships between potential factors and childhood overweight/obesity.

Keywords: associated factors, primary school children, obesity, overweight, Thanhhoa city, Vietnam.

Strengths and limitations of this study

- Variables in the multivariate logistic regression model were selected using the Bayesian Model Averaging method.
- By reason of the growing problems involving the low reproducibility probability in recent years, a factor was only regarded as a statistically significant variable if its p-value was lower than 0.001.
- Causal relationships between factors and overweight/obesity cannot be determined because this is only a cross-sectional study.
- Using a self-administrated questionnaire can also bring about some biases such as recall bias.
- The area under the curve of the multivariate logistic regression model is not high, this model cannot be widely used to prognosticate obesity/overweight status in children.

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Background

As per the World Health Organization (WHO), "overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health" [1]. In 2017, overweight and obesity were the rationales behind the deaths of more than 4 million people. From 1975 to 2016, the prevalence of overweight/obesity among children and adolescents aged 5-19 years rocketed from 4% to 18% [2]. In 2016, globally, there were approximately 340 million overweight/obese children and adolescents aged 5-19 years [1]. In the United States, there was a significant increase in the prevalence of children with overweight and class III obesity from 1999 to 2016 [3]. It is estimated that roughly 33% of children aged 6-11 years and 50% of adolescents aged 12-19 years will become overweight or obese in 2030 [4]. In almost all European countries, from 1999 to 2016, the prevalence of overweight/obesity among children aged 2-13 years was very high, especially in some Mediterranean countries. About 25% of obese children were severely obese [5, 6]. In Vietnam, the prevalence of overweight/obesity among children and adolescents aged 5-19 years soared from 8.5% in 2010 to 19.0% in 2020 [7]. Data from other countries (such as Spain [8], China [9-12], Greece [13], Poland [14], and Australia [15]) also showed the high prevalence of overweight and obesity among children and adolescents. Generally, obesity in childhood is a worldwide epidemic requiring urgent actions and practical interventions.

From 2010 to now, globally, there has been a multitude of studies conducted to determine the prevalence and factors associated with overweight/obesity among children and adolescents [16-44]. The first group of risk factors significantly associated with overweight/obesity among children is the characteristics of children and their families, including child's sex [17-22], child's age [18, 19, 21], birth order [19], overweight at birth [19], the number of siblings [19, 23], school type (public/private) [18, 25], father/mother's education [18, 26, 27], father/mother's occupation [17, 19, 24], parental overweight/obesity or BMIs [18, 19, 24, 29, 30], and residence (urban/rural) [21, 22, 24]. The second group is the dietary habits of children, such as food intake [29], dinner time [26], fast food, sweets, sugary/sweetened drinks [17, 22, 25, 31], and eating vegetables/fruits [29, 32]. Other factors include

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physical activities (exercises/playing sports) [20, 29], mode of transport to school [17, 26], and sedentary activities (watching television, computer game playing, sleeping) [17, 19, 29, 31, 32].

In Vietnam, only two previous studies were conducted in Haiphong city, Vietnam to measure the prevalence of overweight/obesity among primary school children [33, 34]. Thanhhoa is a province located in the central part of Vietnam. Up to now, there is no study conducted in this province to determine associated factors and the prevalence of overweight/obesity among children. This research was conducted to determine the prevalence and associated factors of childhood overweight/obesity among primary school children in Thanhhoa city in 2021. We hypothesized that the characteristics of children and their parents, children's dietary habits, physical activities, and sedentary activities are risk factors associated with overweight/obesity among children in Thanhhoa city.

Methods

This cross-sectional, questionnaire-based survey was carried out in Thanhhoa city, Vietnam from Jan 01 to Feb 28, 2021. This city was chosen for study by reason of the following rationales. Firstly, the first author is living in Thanhhoa city. By virtue of the outbreak of the COVID-19 pandemic, conducting a survey in this place facilitated the data-collection process. In addition, during the time for data collection, Thanhhoa city was devoid of COVID-19 patients and therefore, travel restrictions and social distancing were not applied in this city. Last but not least, the data-collection process was also much easier thanks to the close relationship between authors and leaders of the education industry in Thanhhoa.

Patient and public involvement

No patient involved.

Sample

The study population was primary school children in Thanhhoa city (grade one to five). There are 48 primary schools and about 35,000 primary school students in this city. Seven schools were randomly selected for investigation. Data were collected with the approval of the headmasters/headmistresses of these primary schools. In each school, for each grade, one class was

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randomly selected. All students in these selected classes were recruited in this research, excluding children with amputations or those contracting any chronic/acute health conditions. The sample size was computed using the following formula:

$$n = Z^2_{1-\alpha/2}\frac{p(1-p)}{d^2}\text{Deff}$$

- Deff=1+ICCx(n-1)=1+0.05x(30-1)=2.45 (ICC: interclass correlation for the statistic (ICC=0.05), n=the average size of the clusters (approximately 30 students/class)).

- p=0.221 (from a study conducted in Haiphong city, Vietnam in 2018 [34])

- Z=1.96 (α=0.05), d=0.05 (because 0.1<p<0.3)

The minimum sample size was 700 children. To increase this study's validity and generalizability, a total of 986 children were approached. The response rate was 84.69%. However, after checking data-collection forms, 53 children were excluded from this research because of missing values (Questions in the data-collection forms were not fully answered). The final sample size was 782 children, adequate to achieve a margin of error of 5%, a confidence level of 99%, and a response distribution of 50%.

Questionnaire

In the light of numerous difficulties in directly interviewing children, a self-administrated questionnaire was designed for both children and their parents. Based on the questionnaires of previous studies [19, 25, 27, 29-32], questions were selected, amended, and translated into Vietnamese. Furthermore, two senior lecturers of the University of Medicine and Pharmacy at Ho Chi Minh City aided the research team to review the questionnaire. The final questionnaire which can be seen in Supplemental File 1 included three main parts. Part 1 included questions on socio-demographic characteristics of children and parents. Part 2 focused on investigating the dietary habits of children. Part 3 included questions in relation to children's physical and sedentary activities. To validate the questionnaire, a pilot study was conducted with the participation of 20 children and their parents. The total Cronbach's alpha = 0.85 (the dietary habits of children: 0.67, physical and sedentary activities: 0.81).

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Supplemental File 1

Data collection and anthropometric measurements

Each student was given one data-collection form and one written consent form. Students took these two forms, went home, and filled in these forms in company with their parents. Then, the teachers collected forms from their students. A week later, data collectors came back to selected classes and received data-collection forms and written consent forms from teachers.

For students having both forms, their height and weight were measured by data collectors with the aid of the teachers during playtime. Weight and height were measured for children wearing light clothing without shoes. Weight was measured in kilograms (kg) with the Microlife Weight Scale 50A (manufactured in Sweden) and rounded to the nearest 0.1kg. Each child was measured twice and his/her weight was the average weight. If the difference between the two measurements was more than 0.1kg, a third measurement was carried out. Height was also measured twice with a SECA 222 (a stadiometer manufactured in Germany) and recorded in meters (m) with an accuracy of 0.01m. The WHO Anthro software version 1.0.4 was employed for anthropometric calculation. BAZs (BMI-for-age z-scores) were used to categorized children into groups: thin, normal, overweight, and obese. A child was categorized as thin, overweight, and obese if BAZ<-2SD, 2SD>BAZ>1SD, and BAZ≥2SD, respectively.

Data analysis

Data were analyzed using R software version 4.1.2. The correlations between factors (independent variables) and nutritional status of children were analyzed using the Chi-squared test and Fisher's exact test (when at least one expected value was less than 5). All variables with p-values<0.2 were included in the univariate logistic regression analyses. Variables in the multivariate logistic regression model were selected using the Bayesian Model Averaging method. This model was used to adjust for confounding and explore the associations between factors (independent variables) and the nutritional status of children (dependent variable - a binary variable indicating whether or not children were overweight/obese). The goodness of fit of the multivariate logistic

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model was assessed using the Hosmer–Lemeshow test and the value of area under the curve (AUC). By reason of the growing problems involving low reproducibility probability in recent years, in this study, a factor was only regarded as a statistically significant variable if its p-value<0.001.

Results

Socio-demographic characteristics and health risk factors among primary school children

The average age of children was 8.42 ± 1.36 years old. More than 71% of children came from public schools. Most of the children lived with both parents (88.87%) and another sibling (73.02%). The parental education levels were primarily high school and university (father: 77.36%, mother: 79.15%). The monthly income of most families was lower than 20 million Vietnam dongs (76.22%). (Table 1, Supplemental File 2).

Table 1. Main socio-demographic characteristics and health risk factors among 782 investigated children

No	Children's characteristics and health risk factors		Summary statistics*
1	Child's sex	Male	373 (47.70)
		Female	409 (52.30)
2	Child's age** (months)		101 (87 - 114)
3	Grade	One	145 (18.54)
		Two	159 (20.33)
		Three	177 (22.63)
		Four	170 (21.74)
		Five	131 (16.75)
4	School type	Public	557 (71.23)
		Private	225 (28.77)
5	The number of children in the family (including the child in this study)		2 (2 - 2)
6	Family income per month in 2020 (million Vietnam dongs)		10.0 (7.0 - 16.0)

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No	Children's characteristics and health risk factors		Summary statistics*
7	Father's education	Under secondary	23 (2.94)
		Secondary	74 (9.46)
		High school	238 (30.43)
		University	367 (46.93)
		Post-university	80 (10.23)
8	Father's occupation	Blue-collar worker	515 (65.86)
		White-collar worker	267 (34.14)
9	Mother's education	Under secondary	18 (2.30)
		Secondary	81 (10.36)
		High school	215 (27.49)
		University	404 (51.66)
		Post-university	64 (8.18)
10	Mother's occupation	Blue-collar worker	438 (56.01)
		White-collar worker	344 (43.99)
11	People living with the child	Child's mother and father	695 (88.87)
		Only child's father	9 (1.15)
		Only child's mother	36 (4.60)
		Others (grandparents...)	42 (5.37)
12	Eating after 20:00	Never/Rarely	453 (57.93)
		Sometimes	285 (36.45)
		Usually/Every day	44 (5.63)
13	Eating confectionery, sweet foods	Never/Rarely	125 (15.98)
		Sometimes	549 (70.20)
		Usually/Every day	108 (13.81)

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No	Children's characteristics and health risk factors		Summary statistics*
14	Eating fast food	Never/Rarely	332 (42.46)
		Sometimes	429 (54.86)
		Usually/Every day	21 (2.69)
15	Drinking soda, soft drinks	Never/Rarely	336 (42.97)
		Sometimes	420 (53.71)
		Usually/Every day	26 (3.32)
16	Time of playing sports per week (hours)		0.83 (0 - 2)
17	Time of sedentary activities (hours)		1 (0.5 - 1.5)

*: median (25^{th} - 75^{th} percentile) for continuous variables, number (%) for categorical variables

**: child's age = (2020 - child's birth year) x 12 + (12 - child's birth month)

Exchange rate: 1 million Vietnam dongs = 42.828US$

Rarely: 1-3 days/month or one day/week, Sometimes: 2-4 days/week, Usually: 5-6 days/week.

Supplemental File 2

Regarding children's dietary habits, most of the children had breakfast, lunch, and dinner daily. Only 44 children (5.63%) usually had a meal after 20:00. About three-fifths of children ate vegetables every day/almost every day. The proportions of children usually eating confectionery and fast food were low (13.81% and 2.69%, respectively). Only 26 children (3.32%) drank soda/soft drinks more than five days per week. Regarding children's physical activities, most of the children assisted their parents in doing household chores (86.57%). More than 37% of children did not play sports. Two-fifths of children played sports from one to four times per week. The average time of doing sports among children was 1.50 ± 2.28 hours per week. Only 231 children (29.54%) went to school by themselves (walking: 9.97%, cycling: 19.57%). For sedentary activities, the proportion of children using computers/laptops for recreational activities was extremely low. The number of children watching television and using phones/tablets for more than 3 hours per day was negligible. Only 62 children (7.92%) read books, newspapers, or magazines for more than an hour per day. In

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general, the total time for sedentary activities of almost all children was lower than two hours per day (Table 1, Supplemental File 2).

The nutritional status of children

Overall, the prevalence of overweight/obesity among primary school children in Thanhhoa city was 35.93% (overweight 21.61% and obesity 14.32%). The proportion of overweight girls (20.78%) was nearly equal to that of boys (22.52%) (p=0.6152). However, the proportion of boys with obesity (23.86%) was four times as many as that of girls (5.62%) (p<0.0001) (Fig 1). In addition, the proportion of being overweight/obese among children going to school with the aid of their parents/other adults was higher than that of children walking and cycling to school (38.66%, 32.05%, and 28.10%, respectively). The proportion of being overweight/obese among children whose mothers were white-collar workers was 1.36 times more likely when compared to those whose mothers were blue-collar workers (42.15% and 31.05%, respectively). A high proportion of being overweight/obese was found for children living with only fathers (88.89%) in comparison with those living with both mothers and fathers (34.24%), only mothers (47.22%), and other people (such as grandparents, aunts) (42.86%). (Table 2). The association between the nutritional status of children and other factors can be seen in Supplemental File 2.

Figure 1. The nutritional status of children classified by child's sex

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Table 2. The association between children's nutritional status and factors with p-values<0.2

No	Factors (number of children)		The number of children (%)			p-value
			Overweight	Obesity	Overweight or Obesity	
1	Child's sex	Male (373)	84 (22.52)	89 (23.86)	173 (46.38)	<0.0001
		Female (409)	85 (20.78)	23 (5.62)	108 (26.41)	
2	School type	Public (557)	119 (21.36)	71 (12.75)	190 (34.11)	0.1121
		Private (225)	50 (22.22)	41 (18.22)	91 (40.44)	
3	Number of children in the family	1 (62)	17 (27.42)	15 (24.19)	32 (51.61)	0.0583
		2 (571)	118 (20.67)	81 (14.19)	199 (34.85)	
		3 (125)	28 (22.40)	13 (10.40)	41 (32.80)	
		> 3 (24)	6 (25.00)	3 (12.50)	9 (37.5)	
4	People living with the child	Child's mother and father (695)	143 (20.58)	95 (13.67)	238 (34.24)	0.0021*
		Only child's father (9)	4 (44.44)	4 (44.44)	8 (88.89)	
		Only child's mother (36)	11 (30.56)	6 (16.67)	17 (47.22)	
		Others (42)	11 (26.19)	7 (16.67)	18 (42.86)	
5	Father's education	Under secondary (23)	2 (8.70)	0 (0.00)	2 (8.70)	0.0390
		Secondary (74)	19 (25.68)	10 (13.51)	29 (39.19)	
		High school (238)	48 (20.17)	30 (12.61)	78 (32.77)	
		University (367)	83 (22.62)	59 (16.08)	142 (38.69)	
		Post-university (80)	17 (21.25)	13 (16.25)	30 (37.50)	
6	Father's occupation	Blue-collar worker (515)	107 (20.78)	66 (12.82)	173 (33.59)	0.0693
		White-collar worker (267)	62 (23.22)	46 (17.23)	108 (40.45)	
7	Mother's education	Under secondary (18)	2 (11.11)	0 (0.00)	2 (11.11)	0.0851
		Secondary (81)	18 (22.22)	8 (9.88)	26 (32.10)	

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		High school (215)	45 (20.93)	26 (12.09)	71 (33.02)	
		University (404)	90 (22.28)	69 (17.08)	159 (39.36)	
		Post-university (64)	14 (21.88)	9 (14.06)	23 (35.94)	
8	Mother's occupation	Blue-collar worker (438)	82 (18.72)	54 (12.33)	136 (31.05)	0.0017
		White-collar worker (344)	87 (25.29)	58 (16.86)	145 (42.15)	
9	Family income per month in 2020**	< 10 (284)	52 (18.31)	29 (10.21)	81 (28.52)	0.0011
		10 - 19.99 (312)	70 (22.44)	44 (14.10)	114 (36.54)	
		20 - 29.99 (131)	36 (27.48)	27 (20.61)	63 (48.09)	
		30 or more (55)	11 (20.00)	12 (21.82)	23 (41.82)	
10	Eating confectionery, sweet foods	Never/Rarely (125)	34 (27.20)	24 (19.20)	58 (46.40)	0.0172
		Sometimes (549)	115 (20.95)	76 (13.84)	191 (34.79)	
		Usually/Every day (108)	20 (18.52)	12 (11.11)	32 (29.63)	
11	Time of playing sports	Less than 1h/week (393)	76 (19.34)	50 (12.72)	126 (32.06)	0.0260
		From 1h to 3h/week (284)	78 (27.46)	44 (15.49)	122 (42.96)	
		More than 3h/week (105)	26 (24.76)	22 (20.95)	48 (45.71)	
12	Mode of transport to school	On foot (78)	16 (20.51)	9 (11.54)	25 (32.05)	0.0416
		Bicycle (153)	26 (16.99)	17 (11.11)	43 (28.10)	
		Motorbike/car/bus (551)	127 (23.05)	86 (15.61)	213 (38.66)	
13	Time of sedentary activities	Less than 1h/day (314)	59 (18.79)	43 (13.69)	102 (32.48)	0.1763
		From 1h to 2h/day (398)	85 (21.36)	64 (16.08)	149 (37.44)	
		More than 2h/day (70)	25 (35.71)	5 (7.14)	30 (42.86)	

*: using Fisher's exact test. p-values were calculated using the Chi-squared test and Fisher's exact test to analyze the association between the nutritional status (overweight/obese and normal/thin) and risk factors.

**: unit: million Vietnam dongs. Exchange rate: 1 million Vietnam dongs = 42.828US$

Rarely: 1-3 days/month or one day/week, Sometimes: 2-4 days/week, Usually: 5-6 days/week.

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Factors associated with overweight and obesity among primary school children

The results from the univariate logistic regression model show that childhood overweight/obesity can be associated with child's sex ($p<0.0001$), using a motorbike/car/bus to go to school ($p=0.017$), children living with only their fathers ($p=0.0102$), fathers with under secondary education level ($p=0.030$), mother's occupation ($p=0.0014$), usually eating confectionery ($p=0.0092$), the total time of doing sports per week ($p=0.0076$), and the total time for sedentary activities per day ($p=0.0348$). The results from the multivariate logistic model show that sex, mode of transport to school, people living with the child, and mother's occupation were several factors associated with childhood overweight/obesity. Child's sex was the factor significantly associated with childhood overweight/obesity with $p<0.0001$. Hosmer-Lemeshow goodness of fit test for the multivariate logistic regression model showed that this model can adequately fit the data (X-squared=2.107, df=8, $p=0.9776$). The area under the curve (AUC) of the multivariate logistic regression model was 0.6525 (95%CI: 0.6127-0.6924) (Table 3 and Fig 2).

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Table 3. Factors associated with overweight and obesity among primary school children in Thanhhoa city

No	Factor	Univariate logistic regression		Multivariate logistic regression	
		OR (95% CI)	p-value	aOR (95% CI)	p-value
1	**Child's sex** (reference: Female)				
	Male	2.41 (1.79, 3.26)	< 0.0001	2.48 (1.83, 3.38)	< 0.0001
2	**School** (reference: Private)				
	Public	0.76 (0.55, 1.05)	0.0952		
3	**The number of children in the family** (continuous variable)				
	Per children	0.80 (0.62, 1.01)	0.0694		
4	**Mode of transport to school** (reference: Bicycle)				
	On foot	1.21 (0.66, 2.17)	0.534		
	Motorbike/car/bus	1.61 (1.10, 2.40)	0.017	1.58 (1.12, 2.23)	0.0096
5	**People living with the child** (reference: Both child's mother and father)				
	Only child's father	15.36 (2.80, 285.83)	0.0102	11.96 (2.07, 226.84)	0.0219
	Only child's mother	1.72 (0.87, 3.37)	0.1149		
	Others (grandparents...)	1.44 (0.76, 2.70)	0.2572		
6	**Father's education** (reference: High school)				
	Under secondary	0.20 (0.03, 0.69)	0.030		
	Secondary	1.32 (0.77, 2.26)	0.311		
	University	1.29 (0.92, 1.83)	0.140		
	Post university	1.23 (0.72, 2.08)	0.440		
7	**Father's occupation** (reference: Blue-collar worker)				
	White-collar worker	1.34 (0.99, 1.82)	0.0584		

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No	Factor	Univariate logistic regression		Multivariate logistic regression	
		OR (95% CI)	p-value	aOR (95% CI)	p-value
8	**Mother's occupation** (reference: Blue-collar worker)				
	White-collar worker	1.62 (1.21, 2.17)	0.0014	1.56 (1.15, 2.12)	0.0040
9	**Mother's education** (reference: High school)				
	Under secondary	0.25 (0.04, 0.92)	0.0724		
	Secondary	0.96 (0.55, 1.64)	0.8799		
	University	1.32 (0.93, 1.87)	0.1210		
	Post university	1.14 (0.63, 2.03)	0.6651		
10	**Family income** (continuous variable)				
	Per one million Vietnam dongs	1.01 (1.00, 1.02)	0.0563		
11	**Eating confectionery/sweet foods** (reference: Never/Rarely)				
	Sometimes	0.62 (0.42, 0.91)	0.0158		
	Usually/Every day	0.49 (0.28, 0.83)	0.0092		
12	**The time of doing sports per week** (continuous variable)				
	Per hour	1.09 (1.02, 1.16)	0.0076		
13	**The time for sedentary activities per day** (continuous variable)				
	Per hour	1.19 (1.01, 1.41)	0.0348		

The multivariate logistic regression model was chosen using the Bayesian Model Averaging method. Analysing the relation between two categorical variables was done using Cramer's V. V-values were lower than 0.08 for all pairs of variables in the multivariate logistic regression model. Multicollinearity did not occur in this model.

aOR: adjusted odds ratio, CI: confidence interval

Exchange rate: 1 million Vietnam dongs = 42.828US$

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Figure 2. The receiver operating characteristic (ROC) curve analysis for the multivariate logistic regression model

Discussion

This is the first study conducted in Thanhhoa city to determine the prevalence and risk factors associated with overweight/obesity among primary school children. The results show that among 782 investigated children, 281 children (35.93%) were overweight/obese, congruent with the results of several studies conducted in urban areas/cities in Port Said (2011): 31.2% [35]; Uberaba, Brazil (2012-2013): 32.3% [36]; Ankara, Turkey (2015): 35.9% [27]; and New Zealand (2017-2018): 31.9% [37]. The prevalence of overweight/obesity among primary school children in Thanhhoa is lower than the results of Hochiminh city, Vietnam (2014-2015): 55.6% [38] but far higher than the results of Rikuzentakata, Japan (2013): 7.8% [39]; Guangzhou, China (2014): 18.2% [18]; Chocó, Colombia (2015): 13.2% [40]; Lomé, Togo (2015): 7.1% [32]; Nepal (2017): 25.7% [17]; and Abidjan, Ivory Coast (2018): 10.2% [41]. Therefore, the epidemic of overweight/obesity among primary school children can be regarded as a matter of concern in Thanhhoa city.

Child's sex was the risk factor significantly associated with overweight/obesity among children in Thanhhoa. The odds of being overweight/obese among boys was 2.48 times more likely when compared to girls ($p<0.0001$), in line with the results from studies conducted in urban Nepal [17], Montenegro [19], China [11, 18], and Iran [42]. By contrast, in some other countries, girls were more likely to be overweight/obese than boys, for example in Ethiopia [28] and Ivory Coast [41]. In Brazil, there was no difference in obesity prevalence between boys and girls ($p>0.05$) [43]. There were several possible rationales behind the higher prevalence of overweight/obesity among boys than girls in Thanhhoa city. Firstly, in comparison with girls, the average time (minutes per day) for sedentary activities of boys (73.12) was higher than girls (67.77), including watching television: 37.45 and 32.28, using computers/phones/tablets: 19.65 and 16.79, respectively. This reason was also reported in previous studies in Montenegro [19] and Columbia [45]. In addition, in many countries, male chauvinism is still rife. In Vietnam, many parents hold a belief that girls are less valuable than

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boys and strong fertility desire commonly appears in families without sons [46]. As a result, parents usually cosset their sons more than their daughters. Another possible reason is that boys consumed unhealthy foods (such as fast food) more frequently than girls [47], thereby being able to increase the risk of being overweight/obese. In this study, we only asked children's parents about the frequency of consuming fast food, confectionery, and soda. Future studies should focus on the total intakes of these unhealthy foods to assess their effects on children's nutritional status more specifically.

Besides sex, three other risk factors which could be associated with childhood overweight/obesity included transportation to school, the mother's occupation, and the people living with the child. In Nepal, the mother's occupation was also the risk factor significantly associated with childhood overweight/obesity ($p<0.001$) [17]. Regarding transportation to school, the percentage of children who walked/cycled to school in Thanhhoa (29.54%) was far lower than the result of Lomé, Togo (90.1%) [32] and Port Said city (47.3%) [35]. In Thanhhoa, children going to school with the aid of parents/other adults had more risks of being overweight/obese than those going to school by themselves, in line with the result of a study in Nepal [17]. For the factor involving people living with the child, 88.87% of children in Thanhhoa lived with both parents, similar to the result of Montenegro (91.11%) [19]. By virtue of the low divorce rate, the number of children living with only a father/mother was extremely low (9 and 36 cases, respectively). This can affect the accuracy and the reproducibility of results involving this factor. It is necessary to carry out other studies to re-analyze the effect of this factor on the prevalence of being overweight/obese among children.

Besides the four abovementioned factors, the results from univariate logistic regression show that father's education, confectionery consumption, the time of doing sports, and the time for sedentary activities can be risk factors associated with overweight/obesity among children in Thanhhoa city. In Hanoi, Vietnam, the father's education may be a factor associated with the prevalence of overweight/obesity among children ($p=0.05$) [29]. For sugary/sweetened foods, the proportion of children eating confectionery more than five times/week in Thanhhoa was 13.81%, in line with the result of Nepal (16.9%) [17] but lower than the result of Sharjah, UAE (54.6%) [31]. In

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lieu of overweight/obese children having a higher consumption of confectionery, our results showed a reverse association. In comparison with children never/rarely eating confectionery, the odds of being overweight/obese were respectively 38% and 51% lower than that of children sometimes and usually/every day eating confectionery, in line with the result of a systematic review and meta-analysis [48]. Although eating chocolate and sugar candies may not have pernicious effects on children's health [49], excessive consumption of these types of foods is unnecessary and detrimental in some cases.

Regarding sedentary activities, in Thanhhoa, the odds ratio for being overweight/obese increased 19% for a one-hour increase in the total time of sedentary activities (p=0.0348). In Nepal, sedentary activities were the factor significantly associated with overweight/obesity among children: children spending > 2 hours a day on weekends on sedentary activities were three times more likely to be overweight/obese than those spending ≤ 2 hours a day on weekends [17]. Several previous studies having the same results include Lomé, Togo [32] and Montenegro [19]. For physical activities, playing sports was not the predilection of many primary school children in Thanhhoa. Only 25.58% of children played sports more than three times/week, far lower than the result of China (physical activities ≥ 4 times/week: 45.05%) [30]. There is no denying that physical activities such as doing exercises and playing sports play an important role in helping people to lose weight and keep fit, thereby improving people's health. Children in Thanhhoa city should spend more time doing these beneficial activities.

Our results showed that overweight/obesity should be a problematic matter of concern by virtue of the high prevalence of overweight/obesity among primary school children in Thanhhoa city. By reason of the fairly low AUC, the multivariate logistic regression model cannot be widely used to prognosticate obesity/overweight status in children. However, parents, teachers, and policymakers can implement interventions in factors (such as eating confectionery, playing sports, and sedentary activities) to reduce the rate of childhood obesity. Sports and sedentary activities were associated with dietary patterns and the quality of food choices which can help prevent childhood obesity [50].

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Strengths and limitations

This is the first study conducted to investigate the prevalence and factors associated with overweight and obesity among primary school children in Thanhhoa province. In this study, only p-values less than 0.001 were considered statistically significant by reason of the growing problems involving the low reproducibility probability in recent years. Variables in the multivariate logistic regression model were selected using the Bayesian Model Averaging method.

Besides the aforementioned strengths, this study has some following limitations. Firstly, causal relationships between risk factors and overweight/obesity cannot be determined because this is only a cross-sectional study. Secondly, using a self-administrated questionnaire to collect data can bring about some biases such as recall bias. For factors involving children's dietary habits, we only gather information on the frequency of the meals. Further studies should focus on collecting data on the total intake of various kinds of foods that are strongly associated with overweight/obesity (the portion size). Some factors such as child's birth weight and parental BMIs which may be strongly associated with children's overweight and obesity were not collected. Thirdly, the height of children should be measured in centimeters with an accuracy of 0.1cm, instead of meters with an accuracy of 0.01m. Last but not least, the AUC of the multivariate logistic regression model is not high, this model cannot be widely used to predict obesity/overweight status in children.

Conclusion

One in every three primary school children in Thanhhoa city were either overweight or obese. Besides sex - the significantly associated factor, other potential factors which may be associated with childhood overweight/obesity included mode of transport to school, the people living with the child, mother's occupation, father's education, eating confectionery, the time of playing sports, and sedentary activities. Parents, teachers, and policymakers can implement interventions in these factors to reduce the rate of childhood obesity. In forthcoming years, longitudinal studies should be conducted to determine the causal relationships between potential factors and childhood overweight/obesity.

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Contributors

Le GB: Conceptualization, Methodology, Investigation, Software, Data curation, Project administration, Writing – Review & Editing. **Dinh DX:** Methodology, Investigation, Software, Formal analysis, Data curation, Visualization, Supervision, Project administration, Validation, Writing – Original Draft Preparation, Writing – Review & Editing.

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Competing interests

None declared.

Ethics statements

Ethics approval

The study proposal was approved by the ethics committee of the University of Medicine and Pharmacy at Ho Chi Minh City (number 914/HĐĐĐ-ĐHYD).

Patient consent for publication

Written informed consent was obtained from the parents of all primary school students participating in this research.

Provenance and peer review

Not commissioned; externally peer-reviewed.

Data availability statement

Data are available upon reasonable request. Please contact the corresponding author (dinhxuandai.224@gmail.com) if you are interested in accessing data from our research.

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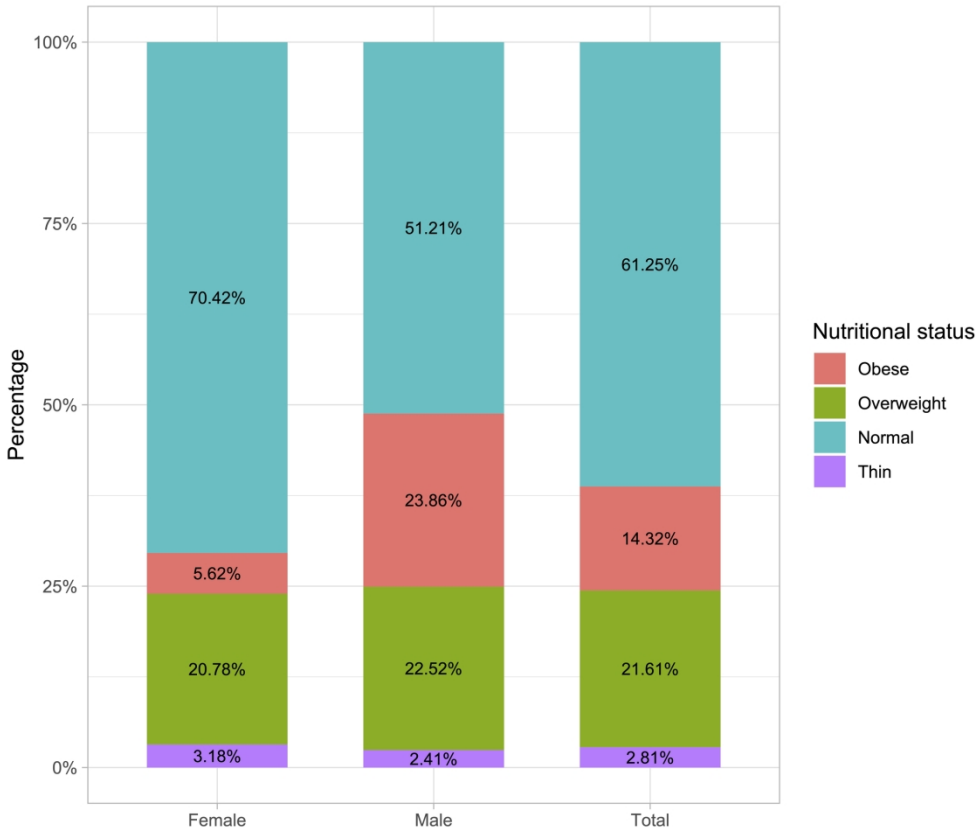

The nutritional status of children classified by child's sex

190x165mm (300 x 300 DPI)

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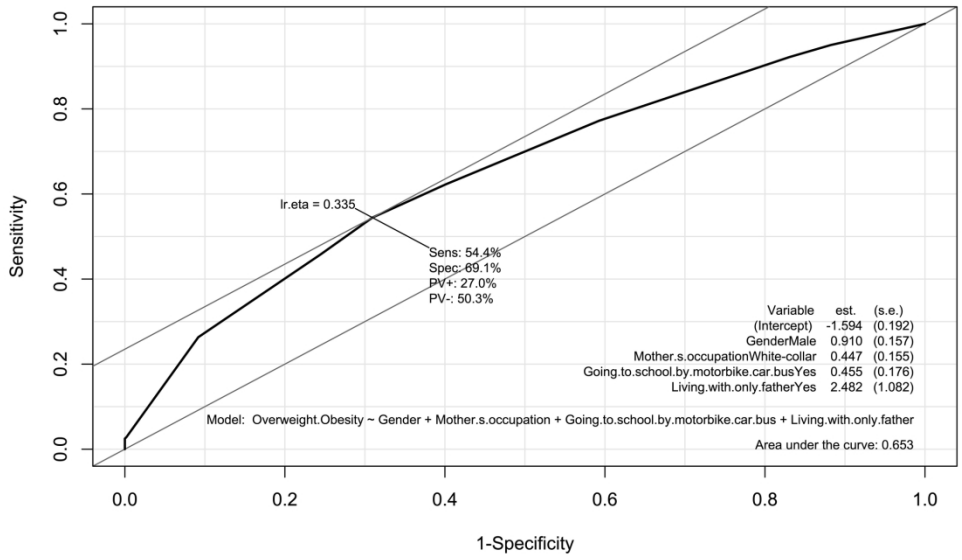

The receiver operating characteristic (ROC) curve analysis for the multivariate logistic regression model

190x125mm (300 x 300 DPI)

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THE SUMMARY QUESTIONNAIRE: Determining the prevalence and factors associated with overweight and obesity among children in Thanhhoa city, Vietnam

For children and their parents

A. Children and parents' information

No	Question	Answer
1	Child's birthday (day/month/year)	..... / ..... / .....
2	The number of children in your family (including the child in this study)	
3	Father's education	☐ Under secondary ☐ Secondary ☐ High school ☐ University ☐ Post-university
4	Father's occupation	☐ Farmer ☐ Worker ☐ Trader ☐ Government worker ☐ Others: .....
5	Mother's education	☐ Under secondary ☐ Secondary ☐ High school ☐ University ☐ Post-university
6	Mother's occupation	☐ Farmer ☐ Household ☐ Worker ☐ Trader ☐ Government worker ☐ Others: .....
7	Family income (per month in 2020)	..... million Vietnam dongs
8	People living with the child	☐ Both father and mother ☐ Only mother ☐ Only father ☐ Others: .....

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B. Children's dietary habits

Note: Rarely: 1-3 days/month or 1 day/week,

Sometimes: 2 - 4 days/week, Usually: 5 - 6 days/week

No	Dietary habits	Answer
1	Eating breakfast	☐ Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Every day
2	Eating lunch	☐ Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Every day
3	Eating dinner	☐ Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Every day
4	Eating after 20:00	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
5	Eating vegetables	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
6	Eating fast food	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
7	Eating confectionery, sweet foods	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day
8	Drinking soda, soft drinks	☐ Never/Rarely ☐ Sometimes ☐ Usually/Every day

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C. Children's physical and sedentary activities

No	Activities	Answer
	Physical activities	
1	Playing sports	☐ Yes ☐ No
1.1	☐ Football	..... times/week x ..... minutes/time
1.2	☐ Skipping	..... times/week x ..... minutes/time
1.3	☐ Shuttlecock kicking	..... times/week x ..... minutes/time
1.4	☐ Running/jogging	..... times/week x ..... minutes/time
1.5	☐ Badminton	..... times/week x ..... minutes/time
1.6	☐ Martial arts	..... times/week x ..... minutes/time
1.7	Other sports:	 ..... times/week x ..... minutes/time ..... times/week x ..... minutes/time ..... times/week x ..... minutes/time
2	Doing household chores	☐ Yes ☐ No
3	Mode of transport to school	☐ On foot/Walking ☐ Bicycle ☐ Motorbike/car/bus (driven by parents/other adults) ☐ Others: .....
	Sedentary activities	
4.1	☐ Watching television	..... minutes/day
4.2	☐ Using computers/laptops	..... minutes/day
4.3	☐ Using phones/tablets	..... minutes/day
4.4	☐ Reading magazines, newspapers, books for fun	..... minutes/day
4.5	Other activities:	 ..... minutes/day ..... minutes/day ..... minutes/day

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For data collectors (collect data when measuring the height and weight of children)

No	Child's information	Answer
1	Name	
2	Sex	☐ Male ☐ Female
3	Grade	☐ One ☐ Two ☐ Three ☐ Four ☐ Five
4	School's name	
5	School type	☐ Public ☐ Private
6	Area (school location)	☐ Urban ☐ Suburb
7	Height	..... meters
8	Weight	..... kilograms

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Supplemental File 2. The association between health risk factors and the nutritional status of children

No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
		Total (782)	**169 (21.61)**	**112 (14.32)**	**281 (35.93)**	**501 (64.07)**	
A	**Demographic and socio-economic characteristics of children and their parents**						
1	Child's sex	Male (373)	84 (22.52)	89 (23.86)	173 (46.38)	200 (53.62)	<0.0001
		Female (409)	85 (20.78)	23 (5.62)	108 (26.41)	301 (73.59)	
2	Child's age (months)	72 to 83 (145)	31 (21.38)	24 (16.55)	55 (37.93)	90 (62.07)	0.2292
		84 to 95 (158)	30 (18.99)	22 (13.92)	52 (32.91)	106 (67.09)	
		96 to 107 (178)	41 (23.03)	34 (19.10)	75 (42.13)	103 (57.87)	
		108 to 119 (170)	35 (20.59)	24 (14.12)	59 (34.71)	111 (65.29)	
		120 to 131 (131)	32 (24.43)	8 (6.11)	40 (30.53)	91 (69.47)	
3	Grade	One (145)	31 (21.38)	24 (16.55)	55 (37.93)	90 (62.07)	0.2045
		Two (159)	30 (18.87)	22 (13.84)	52 (32.70)	107 (67.30)	
		Three (177)	41 (23.16)	34 (19.21)	75 (42.37)	102 (57.63)	
		Four (170)	35 (20.59)	24 (14.12)	59 (34.71)	111 (65.29)	
		Five (131)	32 (24.43)	8 (6.11)	40 (30.53)	91 (69.47)	
4	Area (school location)	Urban (562)	121 (21.53)	84 (14.95)	205 (36.48)	357 (63.52)	0.6721
		Suburb (220)	48 (21.82)	28 (12.73)	76 (34.55)	144 (65.45)	
5	School type	Public (557)	119 (21.36)	71 (12.75)	190 (34.11)	367 (65.89)	0.1121
		Private (225)	50 (22.22)	41 (18.22)	91 (40.44)	134 (59.56)	

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No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
6	The number of children in the family (including the child in this study)	1 (62)	17 (27.42)	15 (24.19)	32 (51.61)	30 (48.39)	0.0146*
		2 (571)	118 (20.67)	81 (14.19)	199 (34.85)	372 (65.15)	
		3 (125)	28 (22.40)	13 (10.40)	41 (32.80)	84 (67.20)	
		4 (18)	6 (33.33)	3 (16.67)	9 (50.00)	9 (50.00)	
		5 (6)	0 (0.00)	0 (0.00)	0 (0.00)	6 (100.00)	
7	Father's education	Under secondary (23)	2 (8.70)	0 (0.00)	2 (8.70)	21 (91.30)	0.0390
		Secondary (74)	19 (25.68)	10 (13.51)	29 (39.19)	45 (60.81)	
		High school (238)	48 (20.17)	30 (12.61)	78 (32.77)	160 (67.23)	
		University (367)	83 (22.62)	59 (16.08)	142 (38.69)	225 (61.31)	
		Post-university (80)	17 (21.25)	13 (16.25)	30 (37.50)	50 (62.50)	
8	Father's occupation	Blue-collar worker (515)	107 (20.78)	66 (12.82)	173 (33.59)	342 (66.41)	0.0693
		White-collar worker (267)	62 (23.22)	46 (17.23)	108 (40.45)	159 (59.55)	
9	Mother's education	Under secondary (18)	2 (11.11)	0 (0.00)	2 (11.11)	16 (88.89)	0.0851
		Secondary (81)	18 (22.22)	8 (9.88)	26 (32.10)	55 (67.90)	
		High school (215)	45 (20.93)	26 (12.09)	71 (33.02)	144 (66.98)	
		University (404)	90 (22.28)	69 (17.08)	159 (39.36)	245 (60.64)	
		Post-university (64)	14 (21.88)	9 (14.06)	23 (35.94)	41 (64.06)	
10	Mother's occupation	Blue-collar worker (438)	82 (18.72)	54 (12.33)	136 (31.05)	302 (68.95)	0.0017
		White-collar worker (344)	87 (25.29)	58 (16.86)	145 (42.15)	199 (57.85)	

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No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
11	People living with the child	Mother and father (695)	143 (20.58)	95 (13.67)	238 (34.24)	457 (65.76)	0.0021*
		Only father (9)	4 (44.44)	4 (44.44)	8 (88.89)	1 (11.11)	
		Only mother (36)	11 (30.56)	6 (16.67)	17 (47.22)	19 (52.78)	
		Others (grandparents, aunts...) (42)	11 (26.19)	7 (16.67)	18 (42.86)	24 (57.14)	
12	Family income per month in 2020 (million Vietnam dongs)	< 10 (284)	52 (18.31)	29 (10.21)	81 (28.52)	203 (71.48)	0.0011
		10 - 19.99 (312)	70 (22.44)	44 (14.10)	114 (36.54)	198 (63.46)	
		20 - 29.99 (131)	36 (27.48)	27 (20.61)	63 (48.09)	68 (51.91)	
		30 or more (55)	11 (20.00)	12 (21.82)	23 (41.82)	32 (58.18)	
B	**Dietary habits of children** (Rarely: 1-3 days/month or one day/week, Sometimes: 2-4 days/week, Usually: 5-6 days/week)						
1	Breakfast	Never (21)	3 (14.29)	4 (19.05)	7 (33.33)	14 (66.67)	0.9312
		Rarely (15)	4 (26.67)	2 (13.33)	6 (40.00)	9 (60.00)	
		Sometimes (25)	5 (20.00)	4 (16.00)	9 (36.00)	16 (64.00)	
		Usually (28)	6 (21.43)	2 (7.14)	8 (28.57)	20 (71.43)	
		Every day (693)	151 (21.79)	100 (14.43)	251 (36.22)	442 (63.78)	
2	Lunch	Never (20)	5 (25.00)	3 (15.00)	8 (40.00)	12 (60.00)	0.8795*
		Rarely (11)	2 (18.18)	1 (9.09)	3 (27.27)	8 (72.73)	
		Sometimes (8)	1 (12.50)	2 (25.00)	3 (37.50)	5 (62.50)	
		Usually (13)	3 (23.08)	3 (23.08)	6 (46.15)	7 (53.85)	
		Every day (730)	158 (21.64)	103 (14.11)	261 (35.75)	469 (64.25)	

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No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
3	Dinner	Never (30)	5 (16.67)	3 (10.00)	8 (26.67)	22 (73.33)	0.6717*
		Rarely (11)	3 (27.27)	2 (18.18)	5 (45.45)	6 (54.55)	
		Sometimes (9)	1 (11.11)	1 (11.11)	2 (22.22)	7 (77.78)	
		Usually (19)	3 (15.79)	3 (15.79)	6 (31.58)	13 (68.42)	
		Every day (713)	157 (22.02)	103 (14.45)	260 (36.47)	453 (63.53)	
4	Eating after 20:00	Never/Rarely (453)	95 (20.97)	69 (15.23)	164 (36.20)	289 (63.80)	0.334
		Sometimes (285)	62 (21.75)	35 (12.28)	97 (34.04)	188 (65.96)	
		Usually/Every day (44)	12 (27.27)	8 (18.18)	20 (45.45)	24 (54.55)	
5	Eating vegetables	Never/Rarely (71)	17 (23.94)	10 (14.08)	27 (38.03)	44 (61.97)	0.4536
		Sometimes (250)	53 (21.20)	29 (11.60)	82 (32.80)	168 (67.20)	
		Usually/Every day (461)	99 (21.48)	73 (15.84)	172 (37.31)	289 (62.69)	
6	Eating confectionery, sweet foods	Never/Rarely (125)	34 (27.20)	24 (19.20)	58 (46.40)	67 (53.60)	0.0172
		Sometimes (549)	115 (20.95)	76 (13.84)	191 (34.79)	358 (65.21)	
		Usually/Every day (108)	20 (18.52)	12 (11.11)	32 (29.63)	76 (70.37)	
7	Eating fast food	Never/Rarely (332)	70 (21.08)	52 (15.66)	122 (36.75)	210 (63.25)	0.4471
		Sometimes (429)	93 (21.68)	56 (13.05)	149 (34.73)	280 (65.27)	
		Usually/Every day (21)	6 (28.57)	4 (19.05)	10 (47.62)	11 (52.38)	
8	Drinking soda, soft drinks	Never/Rarely (336)	69 (20.54)	57 (16.96)	126 (37.50)	210 (62.50)	0.3225
		Sometimes (420)	97 (23.10)	52 (12.38)	149 (35.48)	271 (64.52)	
		Usually/Every day (26)	3 (11.54)	3 (11.54)	6 (23.08)	20 (76.92)	

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No	Factors (number of children)			The number of children (%)				p-value
				Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
C	**Physical and sedentary activities of children**							
1	Doing household chores	Yes (677)		151 (22.30)	91 (13.44)	242 (35.75)	435 (64.25)	0.8664
		No (105)		18 (17.14)	21 (20.00)	39 (37.14)	66 (62.86)	
2	Playing sports	Yes (491)		114 (23.22)	82 (16.70)	196 (39.92)	295 (60.08)	0.0033
		No (291)		55 (18.90)	30 (10.31)	85 (29.21)	206 (70.79)	
3	Types of sports	Football	Yes (191)	50 (26.18)	36 (18.85)	86 (45.03)	105 (54.97)	0.0034
			No (591)	119 (20.14)	76 (12.86)	195 (32.99)	396 (67.01)	
		Skipping	Yes (115)	19 (16.52)	6 (5.22)	25 (21.74)	90 (78.26)	0.0009
			No (667)	150 (22.49)	106 (15.89)	256 (38.38)	411 (61.62)	
		Badminton	Yes (112)	25 (22.32)	20 (17.86)	45 (40.18)	67 (59.82)	0.3654
			No (670)	144 (21.49)	92 (13.73)	236 (35.22)	434 (64.78)	
		Running, jogging	Yes (107)	24 (22.43)	17 (15.89)	41 (38.32)	66 (61.68)	0.6564
			No (675)	145 (21.48)	95 (14.07)	240 (35.56)	435 (64.44)	
		Marterial arts	Yes (40)	14 (35.00)	7 (17.50)	21 (52.50)	19 (47.50)	0.0382
			No (742)	155 (20.89)	105 (14.15)	260 (35.04)	482 (64.96)	
		Cycling	Yes (36)	6 (16.67)	8 (22.22)	14 (38.89)	22 (61.11)	0.841
			No (746)	163 (21.85)	104 (13.94)	267 (35.79)	479 (64.21)	
		Shuttlecock kicking	Yes (21)	4 (19.05)	4 (19.05)	8 (38.10)	13 (61.90)	1
			No (761)	165 (21.68)	108 (14.19)	273 (35.87)	488 (64.13)	

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No	Factors (number of children)			The number of children (%)				p-value
				Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
3	Types of sports	Basketball	Yes (18)	7 (38.89)	5 (27.78)	12 (66.67)	6 (33.33)	0.0124
			No (764)	162 (21.20)	107 (14.01)	269 (35.21)	495 (64.79)	
		Other sports (swimming, table tennis...)	Yes (32)	8 (25.00)	5 (15.63)	13 (40.63)	19 (59.38)	0.7064
			No (750)	161 (21.47)	107 (14.27)	268 (35.73)	482 (64.27)	
4	The number of times playing sports per week	Not playing sports (291)		55 (18.90)	30 (10.31)	85 (29.21)	206 (70.79)	0.0430
		1 to 2 times (187)		43 (22.99)	36 (19.25)	79 (42.25)	108 (57.75)	
		3 to 4 times (146)		37 (25.34)	20 (13.70)	57 (39.04)	89 (60.96)	
		5 to 6 times (69)		16 (23.19)	10 (14.49)	26 (37.68)	43 (62.32)	
		7 times or more (89)		18 (20.22)	16 (17.98)	34 (38.20)	55 (61.80)	
5	The total time of playing sports per week	Not playing sports (291)		55 (18.90)	30 (10.31)	85 (29.21)	206 (70.79)	0.0050
		Less than 1h (102)		21 (20.59)	20 (19.61)	41 (40.20)	61 (59.80)	
		1h - less than 2h (172)		29 (16.86)	28 (16.28)	57 (33.14)	115 (66.86)	
		2h - less than 3h (87)		32 (36.78)	10 (11.49)	42 (48.28)	45 (51.72)	
		3h - less than 4h (48)		12 (25.00)	6 (12.50)	18 (37.50)	30 (62.50)	
		4h or more (82)		20 (24.39)	18 (21.95)	38 (46.34)	44 (53.66)	
6	Mode of transport to school	On foot (78)		16 (20.51)	9 (11.54)	25 (32.05)	53 (67.95)	0.0416
		Bicycle (153)		26 (16.99)	17 (11.11)	43 (28.10)	110 (71.90)	
		Motorbike/car/bus (551)		127 (23.05)	86 (15.61)	213 (38.66)	338 (61.34)	

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No	Factors (number of children)		The number of children (%)				p-value
			Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
7	Watching television	Never (168)	33 (19.64)	14 (8.33)	47 (27.98)	121 (72.02)	0.0208*
		Less than 1h/day (402)	92 (22.89)	70 (17.41)	162 (40.30)	240 (59.70)	
		From 1h to 3h/day (210)	43 (20.48)	28 (13.33)	71 (33.81)	139 (66.19)	
		More than 3h/day (2)	1 (50.00)	0 (0.00)	1 (50.00)	1 (50.00)	
8	Using computers, laptops	Never (687)	141 (20.52)	99 (14.41)	240 (34.93)	447 (65.07)	0.1486*
		Less than 1h/day (78)	24 (30.77)	11 (14.10)	35 (44.87)	43 (55.13)	
		From 1h to 3h/day (16)	3 (18.75)	2 (12.50)	5 (31.25)	11 (68.75)	
		More than 3h/day (1)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	
9	Using phones, tablets	Never (451)	94 (20.84)	70 (15.52)	164 (36.36)	287 (63.64)	0.562
		Less than 1h/day (264)	59 (22.35)	36 (13.64)	95 (35.98)	169 (64.02)	
		From 1h to 3h/day (66)	15 (22.73)	6 (9.09)	21 (31.82)	45 (68.18)	
		More than 3h/day (1)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	
10	Reading books, newspapers, magazines for fun	Never (400)	70 (17.50)	63 (15.75)	133 (33.25)	267 (66.75)	0.0613
		Less than 1h/day (320)	83 (25.94)	40 (12.50)	123 (38.44)	197 (61.56)	
		From 1h to 3h/day (59)	14 (23.73)	8 (13.56)	22 (37.29)	37 (62.71)	
		More than 3h/day (3)	2 (66.67)	1 (33.33)	3 (100.00)	0 (0.00)	
11	The total time of sedentary activities	Less than 1h/day (314)	59 (18.79)	43 (13.69)	102 (32.48)	212 (67.52)	0.1763
		From 1h to 2h/day (398)	85 (21.36)	64 (16.08)	149 (37.44)	249 (62.56)	
		More than 2h/day (70)	25 (35.71)	5 (7.14)	30 (42.86)	40 (57.14)	

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No	Factors (number of children)	The number of children (%)				p-value
		Overweight	Obesity	Overweight or Obesity	Thinness or Normal	
	1. p-values were calculated using the Chi-squared test and Fisher's exact test. *: using Fisher's exact test 2. Occupation: Blue-collar workers (people who do work needing strength or physical skill rather than office work, for example, farmers, drivers, traders). White-collar workers (people who work in offices, doing work needings mental rather than physical effort, for example, doctors, teachers) 3. Exchange rate: 1 million Vietnam dongs = 42.828US$) 4. h: hour					

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	7-8
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	7-8
		(*e*) Describe any sensitivity analyses	NA

Continued on next page

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Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	NA
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*NA*
		Cross-sectional study—Report numbers of outcome events or summary measures	*7-8*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-17
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-17
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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