

Original Research



Double burden of malnutrition in ethnic minority school-aged children living in mountainous areas of Vietnam and its association with nutritional behavior

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ABSTRACT

BACKGROUND/OBJECTIVES: Although children of ethnic minority groups are experiencing a transition from a predominance of undernutrition to overnutrition, there is little evidence of a dual-malnutrition burden. Therefore, this study examined the double burden of malnutrition among school-aged ethnic minority children living in mountainous areas and its association with their diets.

SUBJECTS/METHODS: A cross-sectional study was conducted from September 2019 to March 2020 in 3 mountainous areas of Northern Vietnam among 1,556 ethnic minority school-aged children. The prevalence of under-nutrition (stunting and thinness) and over-nutrition (overweight and obesity) were measured using the WHO 2006 child growth standards (height-for-age and BMI-for-age Z-score). Nutritional practices were evaluated by the frequency of food consumption based on a 4-level scale.

RESULTS: The percentage of children with stunting and thinness were 14.0% and 5.4%, respectively, while the figure for overweight/obesity was 9.4%. The factors positively associated with stunting were living in a family with more than 2 children or being Muong/ other ethnicities compared to the Tay ethnicity. Children who consumed fish/shrimps/crabs or milk weekly/daily were less likely to be undernourished compared to those who never consumed these foods. By contrast, children who never consumed foods rich in vitamin A precursors and vitamin A and fruit or consumed daily snacks/junk food were more likely to be overweight/obese.

CONCLUSIONS: Undernutrition remains a common issue among school-aged children and adolescents of ethnic minority groups, while over-nutrition exists simultaneously. Public health nutrition programs promoting adequate diets and positive lifestyle changes related to nutrition are essential to tackle the double burden of malnutrition among ethnic minority children.

Keywords: Malnutrition; adolescent; ethnic and racial minorities; Vietnam

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Conflict of Interest

The authors declare no potential conflicts of interests.

Author Contributions

Conceptualization: Truong DTT, Tran THT;
Formal analysis: Tran THT, Nguyen TTT;
Funding acquisition: Nguyen TTT, Tran VHT; Investigation: Truong DTT, Nguyen TTT; Methodology: Truong DTT, Tran THT; Supervision: Truong DTT; Writing - original draft: Truong DTT, Tran THT, Nguyen TTT, Tran VHT; Writing - review & editing: Truong DTT, Tran THT, Nguyen TTT, Tran VHT.

INTRODUCTION

Malnutrition is defined as “an imbalance between the need and intake of essential nutrients” [1]. Therefore, the double burden of malnutrition referring to either under- or over-nutrition is presented within individuals, households, and populations throughout their life course [2]. At the individual level, this situation can be manifested by the simultaneous development of 2 or more types of malnutrition (stunting/underweight and overweight/obesity). This burden is also observed at the household level, in which the contrasting forms of malnutrition in multiple family members coexist. Finally, at the population level, the presence of under- and over-nutrition is mentioned in the same community, nation, or region. This phenomenon has profound consequences that can deteriorate individuals' physical and mental development, particularly during childhood and puberty [3,4]. Moreover, this significant public health challenge also places heavy tolls on families, economies, and the healthcare systems [2].

In recent years, Vietnam has achieved a remarkable reduction in child under-nutrition owing to the positive effects of maternal and child health care programs [5]. In addition, the nutrition transition accompanied by rapid economic development and urbanization has promoted the nutritional status of individuals and gradually increased the incidence of overweight/obesity and other non-communicable diseases simultaneously [2,6,7]. Therefore, the transition from a predominance of under-nutrition to over-nutrition, known as the double burden of malnutrition among children, should be considered.

In Vietnam, many ethnic groups live together; the Kinh ethnic group accounts for the largest percentage, approximately 86%, with 53 ethnic minority groups comprising the remainder [8]. Ethnic minorities mostly live in mountainous regions, midlands, or rural parts of the north of Vietnam, while people of the Kinh group live primarily in urban and metropolitan areas. A previous study conducted among school-aged children and adolescents in Ho Chi Minh City, a large metropolitan of Vietnam, reported that 20–30% of primary school were overweight/obese while 6–18% of high school children were under thinness [9]. Although children of ethnic minority groups are experiencing this nutritional transition trend, there is little evidence of a dual-malnutrition burden among those vulnerable subjects.

Adolescence is the period of transition that begins during puberty and ends in early adulthood and is characterized by the development of habits persisting into adult life [10]. Healthy nutrition is critical in this period because it covers deficits in childhood time and provides the required nutrients for adequate physical and cognitive growth to produce stores of energy against illnesses and for improving reproductive health [11]. The available evidence shows that adolescents are becoming increasingly independent in their food choices and factors affecting their nutrition practices include socioeconomic status (age, sex, location, and family income), kinds of food available at home, and lifestyle [10,12,13]. A previous study conducted in Ho Chi Minh City (2019) showed that the percentage of under-nutrition and over-nutrition among secondary school children were 3.8–12.4% and 12.1–28.0%, respectively [9]. In Vietnam, however, there is a scarcity of evidence related to the nutritional status and nutritional practices of school-aged children in ethnic minorities, and the evidence available focuses primarily on children under 5-yr-old instead. Therefore, this examined the double burden of malnutrition among school-aged ethnic minority children living in mountainous areas and its relationship with their diets. This phenomenon is a complex problem, and these findings are crucial for stakeholders to support national planning and appropriate public health policies to tackle the opposite ends of the malnutrition spectrum.

SUBJECTS AND METHODS

Study design and subjects

A cross-sectional study was conducted from September 2019 to March 2020 in 3 mountainous areas in the North of Vietnam, where most ethnic minorities live, including Cao Bang, Phu Tho, and Thai Nguyen. Ethnic minorities often live in mountainous and remote areas in the North of Vietnam. Many villages and communes have 3 to 4 different ethnic groups living together. The geographical location plays a major role in the cultural practices of ethnic minorities and places barriers to accessing infrastructure and public services, such as healthcare and education.

The participants were school-aged children, and the inclusion criteria were as follows: (1) being ethnic minorities of Vietnam, including Tay, Dao, Muong, Cao Lan and others (San Chi, Nung, San Chay, San Diu, Hmong); (2) students who studied in Ethnic Minority Boarding schools in the study settings; and (3) agreed to participate in the study. Children were excluded from the research if (1) they had spinal or vertebral abnormalities that affected their actual height; (2) they had acute diseases/medical conditions affecting their ability to communicate with interviewers.

Sample size and sampling technique

A multiple-stage sampling technique was used to recruit the participants in the study. In each province (Cao Bang, Phu Tho, Thai Nguyen), this study purposely chose one rural and one urban commune, which had a high density of ethnic minority population and reflected the social-economic characteristics of the province. Six communes consisted of Hoa An and Thong Nong (Cao Bang), Doan Hung and Thanh Son (Phu Tho), Vo Nhai, and Dong Hy (Thai Nguyen). In each commune, there was one Ethnic Minority Boarding school. All school students in each Ethnic Minority Boarding school who met the inclusion criteria were recruited to participate in the research. A total of 1,556 students were involved in the study, with a response rate of 98%.

Measure and instruments

Before the interview, interviewers introduced to the participants and their guardians the purpose of the study, the advantages and disadvantages of participating in the study. After that, they signed in the informed consent to confirm their participation. The interviewer-administered questionnaire included the following information.

General information

General information of participants were involved age, gender, ethnic minority, and the number of children in their family.

Anthropometry characteristics

Trained technicians from the Department of Nutrition and Food Safety, Faculty of Public Health, University of Medicine and Pharmacy - Thai Nguyen University took all anthropometric measurements of the children based on the standard protocol. The team leaders had the responsibility to monitor the manipulations of all technicians during the measurement process and check all anthropometric values. All weight scales and height boards were calibrated before conducting the measurements.

- A Japanese SECA scale (SECA, Chiba, Japan) with an accuracy of 0.1 kg was used to measure the weight. When weighing, the participants wore light clothes and no shoes.

Subjects were allowed to stand in the center of the scale, looking straight ahead, and the weight distributed evenly on both legs. The scales were placed in a stable and level position. Weight was indicated in kilograms (kg) with a decimal number. The technician performed the weighing twice, and the results were the average of these 2 weights. The third weighing would be performed if the 2 previous weight measurements were different more than 1 kg.

- The participants' height was measured using wooden height boards with an accuracy of 0.1 mm. The subjects removed their shoes, stood barefoot, with their back to the ruler. The height was indicated in centimeters (cm) with a decimal number. The technician performed the measurement twice and took the average as the final result. A third measure was taken if the 2 previous measurements differed by more than 1 cm.
- The body mass index (BMI) was identified as the weight in kg divided by height in meters squared (m^2).
- The waist circumference was measured using non-elastic tape measures at the midpoint of the lower coastal border and the top of the iliac crest. The hip circumference was measured at the largest circumference around the buttocks.

Regarding undernutrition, stunting was defined as a Z-score < 2 SD based on the height-for-age WHO growth standard for children and adolescents (5–19 yrs old) [14]. In addition, thinness was also used as an indicator for undernutrition, defined as a BMI-for-age Z-score < 2 SD of the WHO growth standard according to age and sex [14]. In terms of overnutrition, overweight/obesity of children aged 5–19 yrs of age was assessed using the BMI-for-age Z-score $> +1$ SD [14].

Health risk behavior related to nutritional status

This study evaluated several risk factors associated with the nutritional status of children and adolescents aged 5–19 yrs old. These factors consisted of skipping breakfast, keeping track of their weight and height, whether having a diet or not, frequency of milk and snacks consumption, washing hands before eating and after using the toilet, and deworming once every 6 mon. The physical activity and sedentary behavior of children were also assessed. According to the recommendation of WHO, children and youth aged 5–17 yrs should accumulate at least 60 min of moderate- to vigorous-intensity physical activities daily, including play, games, sports, transportation, chores, recreation, physical education, or planned exercise [15].

Frequency of food consumption

A list of basic food groups was used, and the frequency of food consumption was assessed based on a 4-level scale (never, monthly/seasonal, weekly, and daily). The groups of food were defined based on the macronutrients [16]: carbohydrate group (rice, white bread, instant noodle, rice noodle/flat rice noodle/rolled rice pancake, potatoes, and tubers); protein group (meat, egg, fish, shrimps and crabs, organ of animal); fat group (fat, cooking oil). In addition, vegetable and fruit, milk and dairy products, and junk food (canned food, soft drinks, sweet food, and snacks/chips) were also assessed separately to assess the food consumption behavior of children further.

Data analysis

Data analysis was performed by STATA 15.1 (StataCorp LLC, College Station, TX, USA) [17]. Descriptive statistics were used to analyze the demographics and nutritional status of the participants. The categorical variables were analyzed using a χ^2 test between boys and girls. A

t-test and Mann-Whitney test were applied to analyze the continuous data. A *P*-value of 0.05 was considered significant.

A multivariate logistic regression model was applied to determine the factors associated with an under- and over-nutrition among ethnic minority school-aged children. Stepwise forward selection strategies were used to establish the reduced regression models. The *P*-value of the log-likelihood ratio test in the stepwise method was 0.2. A *P*-value < 0.05 was considered significant.

Ethics and consents

The research complied with the review process of the Ethics Council of the Thai Nguyen University of Medicine and Pharmacy (code 896A/DHYD - HỒĐỒ) on 8th August 2019, which was based on the principles of the Declaration of Helsinki. The data collection process was conducted under the acceptance of the Department of Education and Training of Cao Bang, Thai Nguyen, and Phu Tho. The data were secured and used only for research purposes. Written informed consent was provided to the participants prior to the research. The participants could refuse or withdraw from the study at any time, which did not disrupt their studying process.

RESULTS

General characteristics of the subjects

Table 1 provides the information of the ethnic minority school-aged children in mountainous areas in Vietnam. The percentage of the Tay ethnicity accounted for the highest (22.4%), followed by the Muong ethnicity (18.1%) and Dao ethnicity (15.6%). The mean age of the subjects was 12.4 (SD = 1.1). Approximately one-third of the participants were in families with more than 2 children, and this percentage was higher among girls than boys. Regarding the anthropometry characteristics, the mean height was 147.5 cm (SD = 8.4). The mean weight, waist, and hip circumference were 39.6 kg (SD = 8.5), 63.1 cm (SD = 6.8), and 76.9 cm (SD = 7.3), respectively. The figures for girls were significantly higher than those for boys. The mean BMI of girls was also significantly higher than that of boys (18.3 and 17.6, respectively).

Table 1. Summary of the general characteristics of ethnic minority school-aged children in mountainous areas

Characteristics	Boy	Girl	Total	<i>P</i> -value
Ethnic				0.36 ¹⁾
Tay	120 (21.3)	229 (23.1)	349 (22.4)	
Dao	94 (16.7)	148 (14.9)	242 (15.6)	
Muong	100 (17.7)	181 (18.3)	281 (18.1)	
Cao Lan	62 (11.0)	83 (8.4)	145 (9.3)	
Others	188 (33.3)	351 (35.3)	539 (34.6)	
No. of children in the family				< 0.01 ¹⁾
≤ 2	449 (79.6)	605 (61.0)	1,054 (67.7)	
> 2	115 (20.4)	387 (39.0)	502 (32.3)	
Age (yrs)	12.4 ± 1.2	12.4 ± 1.1	12.4 ± 1.1	0.19 ²⁾
Height (cm)	147.9 ± 10.3	147.3 ± 7.0	147.5 ± 8.4	0.17 ³⁾
Weight (kg)	39.1 ± 9.4	39.9 ± 7.9	39.6 ± 8.5	< 0.01 ²⁾
Waist circumference (cm)	62.1 ± 7.1	63.6 ± 6.6	63.1 ± 6.8	< 0.01 ²⁾
Hip circumference (cm)	75.3 ± 6.9	77.8 ± 7.4	76.9 ± 7.3	< 0.01 ³⁾
BMI (kg/m ²)	17.6 ± 2.6	18.3 ± 2.7	18.1 ± 2.7	< 0.01 ²⁾

Values are presented as number (%) or mean ± SD.

BMI, body mass index.

¹⁾χ² test; ²⁾Mann-Whitney test; ³⁾t-test.

Nutritional status

Table 2 lists the prevalence estimation of under and overnutrition among the ethnic minority children. Regarding the height for age classification, the percentage of child stunting was 14.0% in general. In addition, the prevalence of thinness among boys in terms of the BMI for age was significantly higher than that of girls (7.3% and 4.3%, respectively). The percentage of being overweight/obese among ethnic children was 9.4%.

Health risk behavior related to the nutritional status

Table 3 lists health risk behavior related to the nutritional status of ethnic minority school-aged children. Approximately 14.0% and 12.7% of participants regularly skipped breakfast and maintained a healthy diet. A higher percentage of children kept track of their weight than their height (63.4% and 41.8%, respectively), and girls followed their weight and height more

Table 2. Nutritional status of ethnic minority school-aged children in mountainous areas using different definitions of under and over-nutrition

Characteristics	Boy	Girl	Total	P-value
Stunting (height for age)	81 (14.4)	136 (13.7)	217 (14.0)	0.72 ¹⁾
BMI for age				0.03 ¹⁾
Thinness	41 (7.3)	43 (4.3)	84 (5.4)	
Normal	466 (82.6)	860 (86.7)	1,326 (85.2)	
Overweight/Obesity	57 (10.1)	89 (9.0)	146 (9.4)	

Values are presented as number (%).

BMI, body mass index.

¹⁾χ² test.

Table 3. Health risk behavior related to the nutritional status of ethnic minority school-aged children in mountainous areas

Characteristics	Boy	Girl	Total	P-value
Regularly skip breakfast	58 (10.3)	159 (16.1)	218 (14.0)	< 0.01 ¹⁾
Keeping track of weight	314 (55.7)	672 (67.7)	986 (63.4)	< 0.01 ¹⁾
Keeping track of height	226 (40.1)	424 (42.7)	650 (41.8)	0.30 ¹⁾
Frequency of keeping track of weight/height				< 0.01 ¹⁾
Everyday	23 (4.1)	29 (2.9)	52 (3.3)	
Every week	143 (25.3)	277 (27.9)	420 (27.0)	
Every month	172 (30.5)	366 (36.9)	538 (34.6)	
Not remember	226 (40.1)	320 (32.3)	546 (35.1)	
Maintaining a healthy diet	64 (11.4)	133 (13.4)	197 (12.7)	0.24 ¹⁾
Frequency of drinking milk				0.50 ¹⁾
None	89 (15.8)	142 (14.3)	231 (14.9)	
Few times per month	7 (1.2)	15 (1.5)	22 (1.4)	
Few times per week	51 (9.1)	111 (11.2)	162 (10.4)	
Everyday	417 (73.9)	724 (73.0)	1,141 (73.3)	
Frequency of having snacks				< 0.01 ¹⁾
Never	15 (2.7)	14 (1.4)	29 (1.9)	
Rarely	70 (12.4)	91 (9.2)	161 (10.3)	
1–3 times/week	175 (31.0)	261 (26.3)	436 (28.0)	
4–6 times/week	100 (17.7)	135 (13.6)	235 (15.1)	
Everyday	204 (36.2)	491 (49.5)	695 (44.7)	
Washing hands before eating and after using the toilet	204 (36.2)	487 (49.1)	691 (44.4)	< 0.01 ¹⁾
Deworming once every 6 mon	451 (80.0)	731 (73.7)	1,182 (76.0)	< 0.01 ¹⁾
Having physical activity				< 0.01 ¹⁾
None	40 (7.1)	87 (8.8)	127 (8.2)	
Not meeting the recommendation	283 (50.2)	691 (69.6)	974 (62.6)	
Meeting the recommendation	241 (42.7)	214 (21.6)	455 (29.2)	
Sedentary behavior (watching TV, using mobile phone, playing video games, reading book, etc.)	524 (92.9)	935 (94.4)	1,459 (93.8)	0.26 ¹⁾
Time of having physical activity (minute per day)	51.8 ± 34.5	37.6 ± 27.1	42.9 ± 30.8	< 0.01 ²⁾
Time of having sedentary behavior (minute per day)	123.5 ± 92.8	113.4 ± 94.9	117.0 ± 94.3	< 0.01 ²⁾

Values are presented as number (%) or mean ± SD.

¹⁾χ² test; ²⁾Mann-Whitney test.

frequently than boys. The percentages of children having milk and snacks every day were 73.3% and 44.7%, respectively. Approximately half of the participants exhibited handwashing behavior before eating and after using the toilet (44.4%), and more than two-thirds of children had deworming treatments once every 6 mon (76.0%). Approximately 29.2% of participants met the recommendation of physical activity for school-aged children (at least 60 min of moderate — to vigorous-intensity physical activity daily), and the mean of time for physical activity was 42.9 min per day (SD = 30.8). The mean time for sedentary behavior was 117 min per day (SD = 94.3).

Frequency of food consumption

Fig. 1 shows the frequency of food consumption among ethnic minority school-aged children in mountainous areas. Most children consumed rice (98.4%) and vegetables (83.0%) every day. Similarly, a higher percentage of participants had meat and fat/cooking oil weekly or daily.

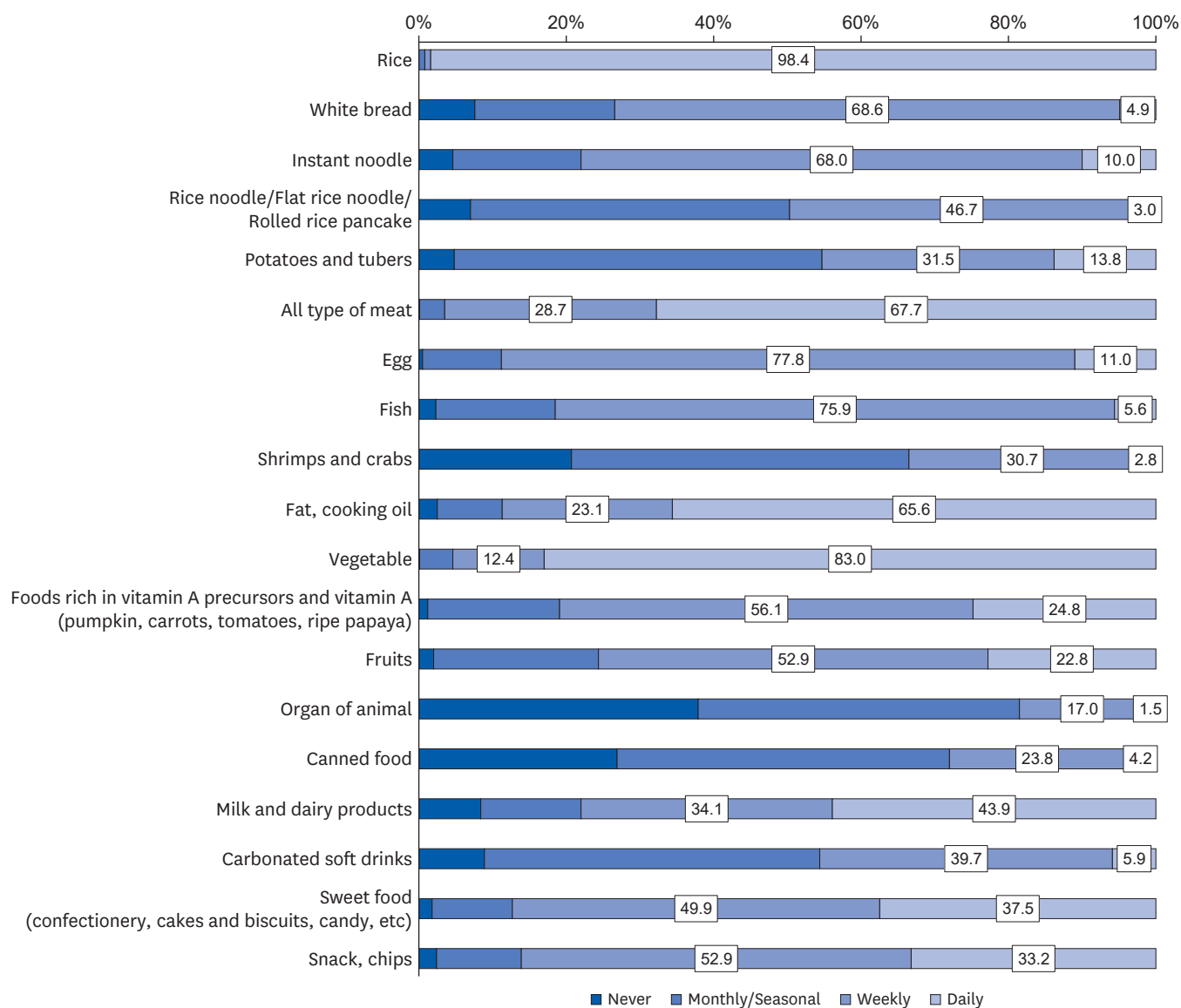


Fig. 1. Frequency of consuming different food types of ethnic minority school-aged children in mountainous areas.

Approximately 33.5% of children ate shrimp/crabs every week or every day. More than 80% of children had sweet food (confectionery, cakes, and candies) or snacks/chips weekly and daily.

Factors related to undernutrition

Table 4 lists factors related to undernutrition among ethnic minority school-aged children in mountainous areas. The factors positively associated with stunting were older age (odds ratio [OR], 1.16; 95% confidence interval [CI], 1.02–1.32), children lived in families with more than 2 children (OR, 1.35; 95% CI, 1.10–1.83), being Muong/other ethnicities compared to the Tay ethnicity. Girls were less likely to be thin than boys (OR, 0.57; 95% CI, 0.36–0.90). Compared to never eating, children who ate potatoes and tubers weekly (OR, 1.45; 95% CI, 1.07–1.96) or daily (OR, 2.37; 95% CI, 1.25–4.49) were more likely to be undernourished. In particular, children who consumed fish/shrimps/crabs monthly/seasonal (OR, 0.29; 95% CI, 0.10–0.81) and weekly/daily (OR, 0.30; 95% CI, 0.12–0.77) were less likely to show stunted growth

Table 4. Factors related to stunted growth and thinness among ethnic minority school-aged children in mountainous areas

Characteristics	Stunting by height for age (Yes vs. No)		Thinness by BMI for age (Yes vs. No)	
	OR	95% CI	OR	95% CI
Age (yrs)	1.16*	1.02–1.32	0.82	0.67–1.00
Gender				
Boy			Ref.	
Girl			0.57*	0.36–0.90
No. of children in the family				
≤ 2	Ref.			
> 2	1.35*	1.10–1.83		
Ethnic				
Tay	Ref.		Ref.	
Dao	1.48	0.89–2.48	0.52	0.23–1.16
Muong	1.73*	1.07–2.81		
Cao Lan	1.32	0.71–2.48	1.94*	1.06–3.55
Others	1.66*	1.08–2.55		
Keeping track of weight				
No			Ref.	
Yes			1.40	0.86–2.26
Maintaining a healthy diet				
No	Ref.			
Yes	1.35	0.90–2.03		
Washing hands before eating and after using the toilet				
No	Ref.			
Yes	0.80	0.59–1.08		
Potatoes and tubers				
Never	Ref.		Ref.	
Weekly	1.45*	1.07–1.96	1.43	0.85–2.43
Daily			2.37*	1.25–4.49
Fat and cooking oil				
Never	Ref.			
Weekly	0.77*	0.55–0.89		
Fish, shrimps and crabs				
Never	Ref.			
Monthly/Seasonal	0.29*	0.10–0.81		
Weekly/Daily	0.30*	0.12–0.77		
Milk and dairy products				
Never	Ref.		Ref.	
Weekly			0.33*	0.12–0.91
Daily	0.77*	0.57–0.91		

OR, odds ratio; CI, confidence interval; BMI, body mass index.
*P < 0.05.

than those never consumed these foods. Those who drank milk weekly (OR, 0.33; 95% CI, 0.12–0.91) and daily (OR, 0.77; 95% CI, 0.57–0.91) were less likely to show stunted growth and thinness than those who never had.

Factors related to overnutrition

Table 5 lists the factors associated with over-nutrition among ethnic minority school-aged children in mountainous areas. Children who kept track of their weight (OR, 0.63; 95% CI, 0.40–0.99), who never/rarely had snack/chips compared to daily consumption (OR, 0.65; 95% CI, 0.43–0.97), and being on a diet (OR, 0.60; 95% CI, 0.37–0.97) were less likely to be overweight/obese. By contrast, those who never/rarely consumed foods rich in vitamin A precursors and vitamin A (OR, 1.41; 95% CI, 1.05–2.04) and never/rarely consuming fruit (OR, 1.61; 95% CI, 1.28–2.66) compared to weekly/daily were positively related to being over-nourished.

DISCUSSION

This study is one of the first in Vietnam to provide empirical evidence on the double burden of malnutrition among ethnic minority school-aged children living in mountainous areas and the association with dietary factors. The findings show that stunted growth was more prevalent than overweight/obesity among ethnic minority children. Households with more than 2 children and children of Muong, Cao Lan, and other ethnicities were more likely to show stunted growth than those with Tay ethnicity. Regarding dietary intake, consuming potatoes and tubers weekly or daily and never having fat and cooking oil were positively related to under-nutrition. By contrast, children who consumed fish, shrimps and crabs, or

Table 5. Factors related to overnutrition among ethnic minority school-aged children in mountainous areas

Characteristics	Overweight/Obesity by BMI for age (Yes vs. No)	
	OR	95% CI
Age (yrs)	1.14	0.96–1.35
Ethnic		
Tay	Ref.	
Dao	1.20	0.72–1.99
Muong	0.51*	0.27–0.95
Cao Lan	0.06*	0.01–0.42
Others	0.49*	0.30–0.80
Keeping track of weight		
No	Ref.	
Yes	0.63*	0.40–0.99
Maintaining a healthy diet		
No	Ref.	
Yes	0.60*	0.37–0.97
Frequency of having snacks		
Weekly/Daily	Ref.	
Never/Rarely	0.65*	0.43–0.97
Food rich in vitamin A precursors and vitamin A		
Weekly/Daily	Ref.	
Never/Rarely	1.41*	1.05–2.04
Fruits		
Weekly/Daily	Ref.	
Never/Rarely	1.61*	1.28–2.66
Canned food		
Weekly/Daily	Ref.	
Never/Rarely	0.73	0.46–1.17

OR, odds ratio; CI, confidence interval; BMI, body mass index.

**P* < 0.05.

milk and dairy products weekly/daily were less likely to show stunted growth and thinness compared to those who never consumed these foods. In terms of over-nutrition, children who ate fruits or food rich in vitamin A precursors and vitamin A weekly/daily had a lower likelihood of being overweight/obese. On the other hand, those who consumed snacks/chips and did not track their weight regularly were more likely to show over-nutrition.

In this study, under-nutrition was more prevalent among ethnic minority children than over-nutrition. This finding is consistent with the result of the National Nutrition Survey of Vietnam 2019–2020 [18], which showed that the percentage of stunting among school-aged children (5–19 yrs old) was 14.8%, while this percentage was 23.4% in 2010 [19]. In addition, the prevalence of overweight/obese children in the present study was also similar to the result of the National Nutrition Survey 2019–2020, indicating that over-nutrition among those living in mountainous areas was 6.9% [18]. A comparison with another study conducted among 24 to 60-mon-old children in the mountainous areas of Vietnam (2019) showed that the proportion of those showing stunted growth in the present study was much lower (29% to 43.9% in different ethnics), while the figure for overweight/obesity was significantly higher (0% to 2.3% in different ethnics) [20]. The prevalence of stunting and thinness among children in the present study was higher than that of the previous study conducted in Ho Chi Minh City, Vietnam, which reported that 3.8% and 4.6% of secondary school children showed stunted growth and were thin, respectively [9]. At the same time, however, the prevalence of overweight/obesity was significantly lower than the study mentioned above (23.5%) [9]. This can be explained by the fact that children from poorer households are more likely to suffer from stunted growth than those from wealthier households, particularly with the predominantly ethnic minority-populated Northern Midlands and Mountainous regions of Vietnam [21]. It is undeniable that childhood undernutrition is rooted in poverty. Ethnic minority groups of Vietnam comprised 14% of the national population but accounted for 73% of the poor in 2016 [21]. This study also found that thinness among boys was more prevalent than among girls. This difference could be based on the biological explanation, in which males are generally more vulnerable and have a higher chance of morbidity and mortality than females in early life [22,23].

Regarding the socioeconomic factors, children in households with more than 2 children were more likely to show stunted growth. Having larger numbers of children or being relatively young are typical demographic characteristics of ethnic minorities in Vietnam, which may increase the risk of poverty regardless of ethnicity [21]. Income poverty among ethnic minority families has a widespread impact on their children's malnutrition and poor education [24]. Many households cannot ensure nutritious meals for their children [25]. In addition, they face food insufficiency for several months per year between the 2 harvests, which increases the burden of malnutrition on their children [25,26]. These findings also show that a low percentage of children strictly followed hygiene requirements, including washing hands before eating and after using the toilet or undergoing deworming treatments once every 6 mon. Previous studies reported that poor sanitation is one of the main reasons for the high stunting proportion in mountainous areas [27–29]. Unhygienic conditions and practices may trigger incipient diarrhea and other digestive-related diseases among children [30].

In terms of the nutritional practices, children who consumed potatoes and tubers daily/weekly compared to monthly/seasonal or never consumed fat/cooking oil were more likely to be undernourished while eating fish, shrimps, and crabs monthly/seasonal or weekly/daily were negatively related to showing stunted growth. These findings are similar to results

from the National Institute of Nutrition report, which indicated that poor energy intake, fatty food, animal fats, and micronutrients were associated with a high level of malnutrition among ethnic children living in mountainous regions [31]. A previous study reported that the meal composition of the mountainous ethnic minorities lacked diversity, predominantly rice, green leafy vegetables, and tubers, which were self-grown staple food crops [32]. Carbohydrates were the main energy supply throughout the year, accounting for more than 60% of the total energy. Other available local food sources were poor, especially protein and iron-rich food, such as meat, fish, eggs, and seafood [32]. Seasonal changes were also considered contributing factors to the lack of these products [33]. For example, in the rainy season, mothers confessed that it was more difficult to feed their children with meat, fish, and seafood because of the inaccessibility of markets. Moreover, in the pre-harvest period, mothers did not want to buy these products because they could not afford them [33]. In addition, children in mountainous areas were less likely to consume some types of seafood, such as fish, shrimps, crabs, eels, snails, and mussels, which resulted from the insufficient nutritional knowledge and practices of the mothers [34]. They were unaware of the nutrient values and how to prepare these food items. In addition, they were afraid of the risk of gastrointestinal problems if their children consumed these foods. Therefore, there has been less attention to ensuring proper nutrition in meals by ethnicities living in mountainous areas. These people only care about having adequate food for 3 meals per day, particularly during the pre-harvest months, which is the peak of food shortages.

Children who consumed milk and dairy products daily or weekly were less likely to show stunted growth or be thin. As part of the school nutritional program to improve the nutritional status of school-aged children, the Vietnamese government introduced a program of giving milk to children daily to reduce the rate of malnutrition and increase the stature and physical strength of children [35]. This program is expected to improve the stature of children in mountainous areas and reduce inequalities of the nutritional conditions between children in remote areas and regions with higher economic conditions. On the other hand, the program is currently being piloted in several provinces, focusing on preschool and primary school children, but improvements in the stunted growth of adolescents enhancements in the adolescent growth spurt are negligible [21]. The skeletal system rapidly grows during adolescence, in which more than 95% of the adult bone mineral content is achieved by the end of this period [36]. Milk makes a vital contribution to bone development, and the recommended amount of consumption for children and adolescents is based primarily on its calcium content [37]. Fortified milk, a good source of calcium and vitamin D, is a vital factor for peak bone mass and high mineral density and is expected to increase the height around puberty [38,39].

In addition to undernutrition, overweight and obesity are increasing in a certain population of school-aged children in mountainous areas. The Muong, Dao, and other ethnic minorities were less likely to be overweight/obese than the Tay people, which is the second-largest ethnic group in Vietnam after the majority Kinh ethnic group [40]. Regarding the food frequency, sweet food was consumed most commonly, followed by snacks and junk food. The consumption of snacks or junk food daily was associated with overnutrition, compared to never/rarely consuming these foods. This can be explained by the available foods in convenient stores with affordable prices and the ability to make independent choices among ethnic boarding children living away from home with reduced parental control. By contrast, the odds of being overweight/obese were lower among those who ate foods rich in vitamin A precursors and vitamin A or fruits daily/weekly than those who never consumed these foods.

This result is consistent with a previous study in that adding vegetables to diets (adjusted OR, 0.26; 95% CI, 0.19–0.35) reduced the chance of developing overnutrition [41]. It was reported that those keeping track of their weight regularly or being on a diet were much less likely of being overweight/obese among children, suggesting the importance of a positive lifestyle in preventing overnutrition. Previous studies also reported differences in the healthy eating habits, level of physical activity, and self-efficacy between children with a normal weight and those with obesity [42,43]. Secondary school-aged children become capable of making independent decisions regarding their diet and exercise in keeping the body fit and healthy [41]. Therefore, increasing self-efficacy and having adequate knowledge of healthy nutrition are essential for obesity management programs among those subjects.

These findings provide critical evidence to develop a long-term strategy to enhance the childhood nutritional status nationally, particularly for adolescent children of minor ethnicities. Several implications can be drawn from this study. First, intervention programs that promote parental nutrition education are essential to reduce the prevalence of stunting and thinness. Such a program is expected to provide sufficient knowledge of the nutrient value of various food types, especially protein and iron-rich foods, and how mothers can prepare foods to avoid gastrointestinal diseases in their children. Second, it is also important to integrate household food security into children's nutrition improvement plans in remote and mountainous areas, supported by taking advantage of locally available foods. Secondary school children of ethnic minorities should benefit from nutritious food and the school milk program of the government to improve their weight and height during puberty. On the other hand, to reduce over-nutrition among children, students should be instructed to self-develop and manage positive lifestyle changes, such as keeping track of their anthropometric indices, building a healthy diet, regularly consuming vegetables and foods rich in vitamin A, and reducing the frequency of eating snacks and junk food.

This study had several limitations. The study design was cross-sectional and could not establish a causal relationship between undernutrition/over-nutrition and the risk factors. In addition, this study assessed nutritional practices based on non-validated food frequency, and the energy intake per day was not taken into account. Finally, recall bias may occur due to differences in the accuracy or completeness of the recollections retrieved by the participants regarding the events or experiences from the past.

Overall, this study showed that undernutrition remains common among school-aged children and adolescents of ethnic minority groups living in the mountainous areas of Vietnam, while the coexistence of over-nutrition is increasing. Moreover, nutritional practices were strongly associated with the nutritional outcomes in children, particularly protein/iron-rich food and milk/dairy products, and a lower risk of showing stunted growth/thin. In addition, self-development and management of positive lifestyle changes related to nutrition should be encouraged in public health nutrition programs and strategies to reduce the risk of overweight and obesity among school-aged children.

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