

**DISTRIBUTION OF BMI-FOR-AGE Z-SCORES BY SEX AND GRADE  
AMONG STUDENTS AT DAI DONG PRIMARY SCHOOL,  
NGHE AN PROVINCE IN 2025**

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**Abstract.** The double burden of malnutrition is an emerging public health challenge in rural Vietnam. The body mass index (BMI)-for-age Z-score (BAZ), based on the WHO 2007 growth reference, provides a continuous metric for nutritional assessment in school-age children. Analyzing BAZ according to school grade is particularly informative because school grade reflects children's cumulative educational and nutritional environments; however, such analyses have remained limited in the Vietnamese literature. This study aimed to describe the distribution characteristics of BAZ and to evaluate differences according to sex and school grade among primary school students at Dai Dong Primary School, Nghe An Province, in 2025. A cross-sectional study was conducted among 887 students (458 boys and 429 girls). BAZ values were calculated using WHO AnthroPlus version 1.0.4. Since BAZ was not normally distributed, non-parametric tests were applied. The results showed that overall median BAZ was  $-0.356$  (interquartile range:  $-1.109$  to  $0.643$ ), significantly below the WHO reference median of  $0$  ( $p < 0.001$ ). The double burden of malnutrition was evident with 19.2% of students classified as overweight or obese, and 6.5% classified as wasted. Boys had significantly higher BAZ values than girls ( $-0.223$  vs.  $-0.463$ ;  $p = 0.020$ ) and a nearly threefold higher prevalence of obesity (10.9% vs. 3.7%;  $p < 0.001$ ). Significant differences in BAZ were observed across school grades ( $p = 0.041$ ), with Grade 3 having the highest median BAZ ( $-0.104$ ), which corresponded to the highest prevalence of overweight/obesity (22.4%). In contrast, the prevalence of wasting increased significantly from Grade 1 (6.3%) to Grade 5 (10.3%) and was highest in Grades 4 and 5 (10.7 and 10.3%, respectively;  $\chi^2 = 20.33$ ,  $p < 0.001$ ). A double burden of malnutrition exists in this rural primary school population. Grade 3 exhibited the highest burden of overweight/obesity, while upper grades (4–5) showed a marked increase in wasting, underscoring the need for grade-specific nutritional surveillance and targeted interventions.

**Keywords:** BMI-for-age Z-score, double burden of malnutrition, primary school children, sex differences, Nghe An.

## 1. Introduction

Childhood nutrition during the primary school years (6 - 11 years) is a critical determinant of cognitive development, academic performance, and long-term health [1]. Over the past two decades, Vietnam has undergone a rapid nutrition transition characterised by the simultaneous persistence of undernutrition and a surge in overweight and obesity – the so-called “double burden of malnutrition” [2], [3]. The most recent nationally representative data from the South East Asian Nutrition Surveys II (SEANUTS II Vietnam, 2020–2021;  $n = 4,001$  children aged 0.5 - 11.9 years) showed that 23.4% of Vietnamese children aged 0.5–11.9 years were overweight or obese, with a significant urban–rural gradient (urban: 34.9%; rural: 15.9%), while stunting remained at 8.7% [4]. Importantly, SEANUTS II also documented that obesity was significantly more prevalent in boys (13.9%) than girls (6.9%) [4], highlighting a consistent sex disparity in overnutrition.

BMI-for-age Z-score (BAZ), based on the WHO 2007 growth reference [5], is the recommended indicator for assessing the nutritional status of children aged 5 - 19 years. Although age-based analysis is standard in epidemiological studies, in Vietnamese primary schools, school grade serves as a practical and administratively relevant unit for organizing health and education interventions. Nutrition programs, physical education curricula, and school feeding schemes are typically implemented by grade rather than by precise age. Therefore, analysing BAZ by grade provides findings that are directly actionable for school administrators and public health practitioners, complementing conventional age-based approaches. In addition, within a single-school context, grade-level grouping may reduce heterogeneity in social and academic exposures compared with age-based grouping, which can span different school environments. Accordingly, analysing BAZ distribution across school grades, rather than chronological age alone, thus offers both conceptual and operational value, as school grade captures not only age but also the cumulative influence of the school environment, dietary habits, and physical activity patterns specific to each level of primary education [6]. However, grade-stratified BAZ distribution analyses remain scarce in the Vietnamese literature, particularly for rural north-central regions. Existing studies have largely focused on urban or mixed settings, leaving a gap in context-specific evidence needed to inform school-based nutrition surveillance and intervention planning in rural areas. For example, a cross-sectional study of 3,108 primary school children aged 6 - 10 years in urban Hanoi reported a predominance of overnutrition (23.4% overweight and 17.3% obese), highlighting the relevance of examining this specific age range within primary school contexts [7]. Similarly, a cross-sectional study among 1,861 students aged 6–14 years in Thai Nguyen city, a provincial urban centre in northern Vietnam, reported a double burden of malnutrition, with a prevalence of 28.6% for overweight/obesity and 12.3% for thinness [8]. These findings underscore the broader public health relevance of understanding how the double burden manifests across different educational contexts, suggesting that it is not confined to major metropolitan areas but also extends to smaller urban centres and potentially rural settings.

Dai Dong Commune, Nghe An Province, is a rural agricultural community in north-central Vietnam. To our knowledge, no systematic, grade-stratified nutritional assessment has previously been conducted in this setting. By addressing this gap, the present study contributes not only descriptive data but also evidence with practical implications for

school-based nutrition monitoring and targeted intervention design in rural Vietnam, particularly in the context of the emerging double burden of malnutrition. This study aimed to: (1) describe the overall BAZ distribution at Dai Dong Primary School and compare it with the WHO 2007 reference; (2) examine sex-specific differences in BAZ and nutritional status; and (3) analyse BAZ distribution characteristics and nutritional status across school grades.

## **2. Materials and methods**

### **2.1. Study design and participants**

A school-based cross-sectional study was conducted at Dai Dong Primary School, Yen Thanh District, Nghe An Province, from September to December 2025. All students enrolled in Grades 1–5 with complete anthropometric data were eligible. Exclusion criteria were: (1) absence on the measurement day; (2) medical conditions affecting body composition; or (3) implausible BAZ values ( $BAZ < -10$ , considered likely data entry errors;  $n = 2$ ). The final sample comprised 887 students with a mean age of  $7.91 \pm 1.46$  years. Age was calculated as the difference between the date of anthropometric measurement and the date of birth, expressed in decimal years. Informed written consent was obtained from parents or legal guardians.

### **2.2. Anthropometric measurements**

Body weight was measured using a calibrated TANITA HD-660 digital scale (precision, 0.1 kg) in light clothing without shoes. Standing height was measured using a wall-mounted stadiometer (precision: 0.1 cm) with students in the Frankfurt plane. All measurements followed the standardised protocol of the National Institute of Nutrition of Vietnam [9]. BAZ was calculated using WHO AnthroPlus v1.0.4 [5].

### **2.3. Nutritional status classification**

Nutritional status was classified using WHO 2007 BAZ cut-offs [5]: severe wasting ( $BAZ < -3$  SD); moderate wasting ( $-3 \leq BAZ < -2$  SD); normal ( $-2 \leq BAZ \leq +1$  SD); overweight ( $+1 < BAZ \leq +2$  SD); obese ( $BAZ > +2$  SD). Combined wasting was defined as  $BAZ < -2$  SD; combined overweight/obese (OW/OB) was defined as  $BAZ > +1$  SD.

### **2.4. Statistical analysis**

Data were analysed using Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Age was summarized as mean  $\pm$  SD (normally distributed; Shapiro-Wilk test:  $p = 0.062$ ). The normality of BAZ was rejected by both Shapiro-Wilk ( $W = 0.987$ ,  $p < 0.001$ ) and Kolmogorov-Smirnov tests ( $D = 0.053$ ,  $p = 0.013$ ); therefore, BAZ was summarized as median (Interquartile Range, IQR). Between-sex comparisons used the Mann-Whitney U test. Grade comparisons used the Kruskal-Wallis test; post-hoc pairwise Mann-Whitney U tests with Bonferroni-adjusted pairwise tests were applied where the omnibus test was significant. Proportional differences were assessed using Chi-square tests. BAZ values were calculated based on the WHO 2007 growth reference, for which the reference distribution is standardized with a mean ( $\mu$ ) of 0 and a standard deviation ( $\sigma$ ) of 1. The empirical

distribution of BAZ was visually compared with the WHO reference normal distribution  $N(0,1)$ . Kernel density estimation (KDE) was used to illustrate the sample distribution, while the WHO reference curve was generated from the theoretical standard normal distribution. To statistically assess deviation from the WHO reference, the median BAZ was compared with the reference median of zero using a one-sample Wilcoxon signed-rank test. Distributional characteristics were further explored by calculating skewness and kurtosis in Microsoft Excel using the SKEW and KURT functions, together with visual inspection of the histogram. Skewness and kurtosis values were interpreted descriptively, with absolute values close to zero considered indicative of approximate symmetry. All statistical tests were two-sided, and  $p < 0.05$  was considered statistically significant.

### 3. Results and discussion

#### 3.1. Characteristics of the study participants

*Table 1. Characteristics of the study participants (n = 887)*

Characteristics	Overall (n = 887)	Boys (n = 458)	Girls (n = 429)	p-value
<b>School grade, n (%)</b>				
Grade 1	127 (14.3)	74 (58.3%)	53 (41.7%)	0.142 <sup>a</sup>
Grade 2	164 (18.5)	76 (46.3%)	88 (53.7%)	
Grade 3	205 (23.1)	109 (53.2%)	96 (46.8%)	
Grade 4	206 (23.2)	97 (47.1%)	109 (52.9%)	
Grade 5	185 (20.9)	102 (55.1%)	83 (44.9%)	
Age (years)	7.9 ± 1.5	7.9 ± 1.5	7.9 ± 1.4	0.808 <sup>b</sup>
Weight (kg)	24.0 (21.0–29.0)	25.0 (21.0–30.0)	24.0 (20.0–28.0)	<b>0.040<sup>c</sup></b>
Height (cm)	125.0 (118.0–133.0)	126.0 (119.0–132.8)	125.0 (118.0–133.0)	0.460 <sup>c</sup>
BMI (kg/m <sup>2</sup> )	15.4 (14.2–17.3)	15.5 (14.3–17.8)	15.2 (14.1–16.9)	<b>0.003<sup>c</sup></b>
BAZ	−0.356 (−1.109–0.643)	−0.223 (−1.094–0.849)	−0.463 (−1.151–0.416)	<b>0.020<sup>c</sup></b>

BAZ: BMI-for-age Z-score; Bold: statistically significant ( $p < 0.05$ ).

<sup>a</sup> Data are presented as n (%), compared using the Chi-square test for categorical variables.

<sup>b</sup> Data are presented as mean ± SD, compared using an independent samples t-test, for normally distributed variables.

<sup>c</sup> Data are presented as median (IQR), compared using the Mann–Whitney U test for non-normally distributed variables

Table 1 summarises participant characteristics. The study included 887 primary school students, comprising 458 boys (51.6%) and 429 girls (48.4%). The distribution of participants across school grades was relatively balanced, ranging from 14.3% in Grade 1

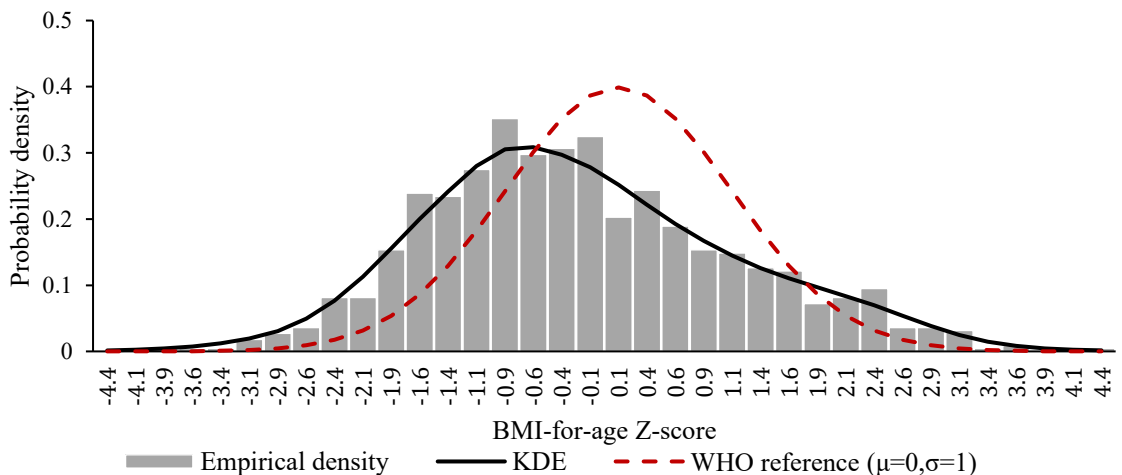
to 23.2% in Grade 4, with no significant sex difference ( $p = 0.142$ ). The mean age of participants was  $7.9 \pm 1.5$  years and was comparable between boys and girls ( $p = 0.808$ ).

Boys had a significantly higher median weight than girls (25.0 vs. 24.0 kg,  $p = 0.040$ ), whereas height did not differ significantly by sex ( $p = 0.460$ ). Median BMI was significantly higher in boys than in girls (15.5 vs. 15.2 kg/m<sup>2</sup>,  $p = 0.003$ ). Similarly, boys had significantly higher BMI-for-age Z-scores (BAZ) than girls ( $-0.223$  vs.  $-0.463$ ,  $p = 0.020$ ).

### 3.2. Overall BMI-for-age Z-score distribution

The overall median BAZ was  $-0.356$  (IQR:  $-1.109$  to  $0.643$ ), significantly below the WHO reference median of zero (one-sample Wilcoxon signed-rank test,  $p < 0.001$ ). The BAZ distribution was non-normal and slightly right-skewed (skewness =  $0.37$ , kurtosis =  $-0.097$ ), indicating a modestly longer right tail towards overnutrition. Figure 1 illustrates the empirical BAZ density alongside the WHO reference curve, demonstrating the leftward shift of the sample distribution relative to the reference.

This result suggests that BMI-for-age Z-score values among students were generally positioned below the international reference median. The distribution was non-normal and had slightly negative kurtosis, reflecting a relatively broad and flattened pattern with modest asymmetry toward higher BAZ values. Together, these features indicate that the observed distribution deviated from the theoretical WHO normal distribution, highlighting heterogeneous nutritional variation within the study population. This finding is consistent with national SEANUTS II Vietnam data (2020 - 2021), which reported a similar downward shift in mean BAZ among rural children compared with urban peers [4]. This approach is recommended but inconsistently applied in Vietnamese school nutrition studies [10].

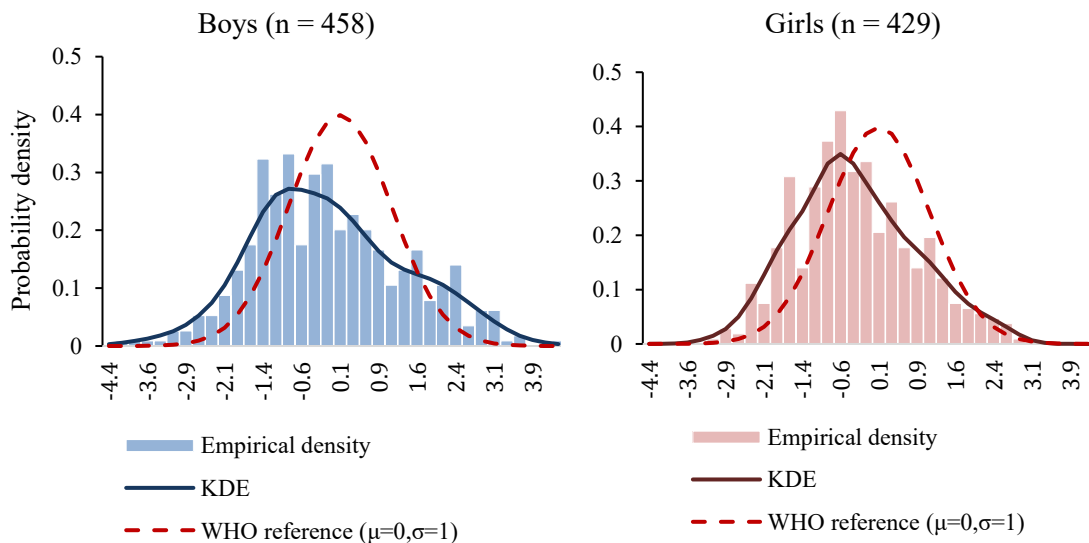


**Figure 1. Empirical distribution of BMI-for-age Z-score compared with the WHO 2007 reference distribution among students at Dai Dong Primary School, Nghe An Province**

*KDE: Kernel density estimate*

### 3.3. BMI-for-age Z-score and nutritional status by sex

Figure 2 displays sex-stratified BAZ distributions. In both boys and girls, the empirical BAZ distributions were shifted to the left of the WHO reference curve, indicating overall lower BAZ values relative to the reference population. Boys exhibited a slightly broader distribution with a modest right tail, whereas girls demonstrated a more concentrated distribution around the central range. Despite these differences in dispersion, both sexes displayed similar overall patterns of leftward displacement compared with the WHO standard.



**Figure 2. Empirical distribution of BMI-for-age Z-score by sex compared with the WHO 2007 reference distribution among students at Dai Dong Primary School, Nghe An Province**

*KDE: Kernel density estimate*

Table 2 presents nutritional status and BAZ by sex. Boys had a significantly higher median BAZ than girls ( $-0.223$  vs.  $-0.463$ ; Mann-Whitney U,  $p = 0.020$ ) and a wider interquartile range (IQR:  $-1.094$  to  $0.849$  vs.  $-1.151$  to  $0.416$ ). Overall OW/OB prevalence was 19.2%; 22.9% in boys versus 15.2% in girls ( $\chi^2 = 8.15$ ,  $p = 0.004$ ). Obesity was nearly threefold higher in boys (10.9% vs. 3.7%;  $\chi^2 = 15.59$ ,  $p < 0.001$ ). Wasting prevalence did not differ significantly by sex (7.0% boys vs. 6.1% girls;  $p = 0.673$ ).

These findings suggest a clear coexistence of overnutrition and undernutrition within the same school population, with 19.2% OW/OB and 6.5% wasting, reflecting a double burden of malnutrition. Compared with prior national data, the OW/OB prevalence observed in this rural school is comparable to the rural estimate reported in SEANUTS II (15.9%) [4] and is markedly higher than that reported in SEANUTS I ( $\sim 5.6\%$ ) [11], indicating a rapid increase in overnutrition in rural Vietnam over the past decade.

This pattern is consistent with other Vietnamese studies. Earlier data from Hanoi (2011) showed that overnutrition predominated over undernutrition, with 23.4% overweight and 17.3% obesity, compared with very low rates of stunting and wasting,

suggesting that the shift toward overnutrition has been ongoing for more than a decade [7]. Together, these findings indicate that rural and peri-urban areas are increasingly experiencing similar nutritional transitions.

**Table 2. Nutritional status according to sex among students at Dai Dong Primary School, Nghe An Province**

<b>Nutritional Status</b>	<b>Overall n (%)</b>	<b>Boys n (%)</b>	<b>Girls n (%)</b>	<b><math>\chi^2</math></b>	<b>p-value</b>
Severe wasting	8 (0.9)	7 (1.5)	1 (0.2)		
Moderate wasting	50 (5.6)	25 (5.5)	25 (5.8)		
<i>Total wasting</i>	<i>58 (6.5)</i>	<i>32 (7.0)</i>	<i>26 (6.1)</i>	0.18	0.673
Normal	659 (74.3)	321 (70.1)	338 (78.8)		
Overweight	104 (11.7)	55 (12.0)	49 (11.4)		
Obese	66 (7.4)	50 (10.9)	16 (3.7)		
<i>Total overweight/obese</i>	<i>170 (19.2)</i>	<i>105 (22.9)</i>	<i>65 (15.2)</i>	8.15	<b>0.004</b>

*BAZ: BMI-for-age Z-score;  $\chi^2$  and p-values were calculated using the Chi-square test.*

*Bold: statistically significant ( $p < 0.05$ ).*

Simultaneously, the prevalence of wasting exceeds the WHO threshold for public health concern (5%) [12], indicating that undernutrition remains a relevant issue in this setting. These findings are consistent with SEANUTS II Vietnam, which reported the coexistence of persistent undernutrition and increasing overnutrition in rural areas [4].

Compared with previous studies, Nguyen et al. [13] reported that the combined overweight and obesity prevalence was 19% among Vietnamese children aged 5 - 19 years as of 2020, with annual growth rates among the fastest in Southeast Asia, and confirmed that males faced significantly higher risks (OR for females = 0.48, 95% CI: 0.46 - 0.51) [12].

Regarding sex differences, the significantly higher BAZ and obesity prevalence in boys are consistent with findings from SEANUTS II Vietnam, where obesity was significantly more prevalent in boys than girls across the national sample [4]. This pattern is consistent with both national data and prior local studies, including findings from Hanoi, where boys had substantially higher obesity prevalence than girls across age groups [7]. Evidence from a case-control study in Hanoi further suggests that behavioral factors, such as eating quickly, overeating, and shorter sleep duration, are associated with increased obesity risk in primary school boys [14]. In prior studies, this sex disparity has been attributed to differences in dietary behaviour, physical activity patterns, and parental feeding practices [15]; however, these factors were not measured in the present study, and the underlying mechanisms in this population remain to be elucidated. These findings suggest that obesity prevention programs should be sex-targeted, with boys as the primary focus.

### **3.4. BMI-for-age Z-score and nutritional status by school grade**

Table 3 presents BAZ and nutritional status by school grade. A statistically significant difference in BAZ across grades was found (Kruskal-Wallis H = 9.97, p = 0.041). Post hoc pairwise comparisons (Bonferroni-corrected) revealed significant differences between Grade 2 and Grade 3, and between Grade 3 and Grade 4, with Grade 3 having the highest median BAZ (-0.104).

**Table 3. BMI-for-age Z-score by school grade among students at Dai Dong Primary School, Nghe An Province**

Grade	Age (years)	BAZ	Min BAZ	Max BAZ
1 (n = 127)	5.63 ± 0.60	-0.254 (-1.357-0.544)	-3.776	4.264
2 (n = 164)	6.76 ± 0.47	-0.536 (-1.004-0.473)*	-2.932	3.432
3 (n = 205)	7.76 ± 0.50	-0.104 (-0.875-0.786)	-4.127	3.662
4 (n = 206)	8.72 ± 0.53	-0.525 (-1.327-0.481)*	-3.549	3.693
5 (n = 185)	9.77 ± 0.44	-0.157 (-1.075-0.701)	-3.402	2.994
p-value	< <b>0.001</b> <sup>a</sup>	<b>0.041</b> <sup>b</sup>	-	-

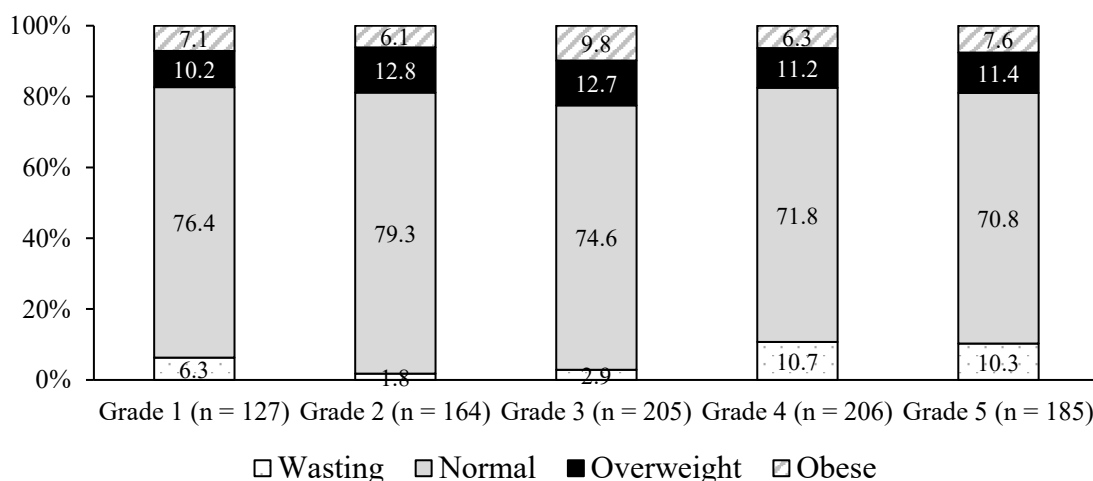
BAZ: BMI-for-age Z-score. Bold p-values indicate statistical significance at  $p < 0.05$ .

\* $p < 0.05$  compared with Grade 3 in Bonferroni-corrected post-hoc pairwise comparisons.

<sup>a</sup> Data are presented as mean ± SD and compared among grades using one-way ANOVA for normally distributed variables. <sup>b</sup> Data are presented as median (IQR) and compared among grades using the Kruskal–Wallis test for non-normally distributed variables.

Figure 3 illustrates the distribution of nutritional status across school grades. The majority of students in all grades were classified as having normal nutritional status, ranging from 70.8% to 79.3%. Wasting prevalence varied significantly across grades ( $\chi^2 = 20.33$ ,  $df = 4$ ,  $p < 0.001$ ), showing a marked escalation in upper grades: from 1.8% in Grade 2 to 10.7% in Grade 4 and 10.3% in Grade 5. In contrast, the prevalence of OW/OB remained relatively stable across grades. Overweight ranged from 10.2% to 12.8% ( $\chi^2 = 0.705$ ,  $p = 0.951$ ), while obesity ranged from 6.1% to 9.8% ( $\chi^2 = 2.380$ ,  $p = 0.666$ ), with no statistically significant differences observed between grades.

$\chi^2 = 20.33$ ,  $p < 0.001$  for wasting prevalence  
 $\chi^2 = 0.705$ ,  $p = 0.951$  for overweight prevalence  
 $\chi^2 = 2.380$ ,  $p = 0.666$  for obese prevalence



**Figure 3. Nutritional status distribution (%) by school grade among students at Dai Dong Primary School, Nghe An Province**

The p-values were obtained using the Chi-square test.

The analysis by school grade reveals two distinct, clinically important patterns. First, Grade 3 (age ~7.8 years) had the highest median BAZ and OW/OB prevalence (22.4%), significantly higher than Grade 2 and 4. This mid-primary school peak in overnutrition may indicate a grade-level difference observed in our sample and is consistent with patterns reported in previous studies; whether concurrent energy surplus or other unmeasured dietary factors contributed to the elevated BAZ observed in Grade 3 warrants further investigation [16], [17]. SEANUTS II similarly reported increasing overweight and obesity from the youngest to the older age groups [4], supporting a developmental trajectory of increasing overnutrition through the school years in Vietnam. Second, and more concerning, wasting prevalence increased sharply from Grade 2 (1.8%) to Grades 4–5 (~10%), a significant trend ( $p < 0.001$ ). This pattern may reflect progressive dietary inadequacy as children advance through school. An alternative or complementary explanation is the pre-pubertal growth spurt: students in Grades 4–5 (aged ~9–11 years) approach puberty, and in girls, particularly, height may increase rapidly (>10 cm/year) while weight gain does not keep pace, resulting in a transiently lower BAZ [18]. The study has several notable strengths. First, whole-school sampling minimized the potential for selection bias. Second, nutritional status was assessed using WHO-standardised BMI-for-age Z-scores, ensuring comparability with international references. Third, grade-stratified analyses were conducted using appropriate non-parametric methods consistent with the observed data distributions. Finally, this represents the first school-based nutritional assessment conducted in this rural community.

However, several limitations should be acknowledged. The cross-sectional design precludes causal interpretation of observed associations, and the inclusion of a single school restricts external generalisability. Furthermore, the analysis was primarily univariate; no multivariable models were constructed to assess independent associations of sex or grade with nutritional status. The absence of data on dietary intake, physical activity, pubertal status, and socioeconomic factors precluded examination of the contextual mechanisms underlying the observed grade- and sex-specific patterns. Future studies incorporating these covariates and multivariable analytic approaches are needed to clarify the determinants of the double burden in comparable rural school populations.

#### **4. Conclusions**

Among primary school students at Dai Dong Primary School, Nghe An Province, the distribution of BAZ was shifted below the WHO reference median and was non-normally distributed. A double burden of malnutrition was observed, with substantial coexistence of overweight/obesity and wasting in the same population. Boys had significantly higher BAZ and obesity prevalence than girls. Grade-stratified analysis identified mid-primary grades as a period of peak overweight/obesity burden and upper primary grades as a period of wasting escalation. These findings provide baseline evidence for grade-specific, sex-sensitive nutritional surveillance and interventions in rural primary schools of north-central Vietnam. Given the single-school, cross-sectional design, generalisation beyond this setting requires replication in larger, multi-site studies.

**Note for contributor:**

- Short bio: Nguyen Thi Hong Hanh is a lecturer at Hanoi National University of Education, Hanoi, Vietnam; Nguyen My Duyen is a teacher at Hung Vuong Secondary School, Ho Chi Minh City, Vietnam.

- Author's contributions: Nguyen Thi Hong Hanh: conceptualization, methodology, supervision, visualization, writing, review & editing; Nguyen My Duyen: data collection, data analysis.

**Conflict of interest:** The authors declare no conflict of interest.

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