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THE CHANGES IN ANTHROPOMETRIC INDICES AND NUTRITIONAL STATUS AMONG PRESCHOOL CHILDREN IN A RURAL AREA OF THE RED RIVER DELTA, VIETNAM: A REPEATED CROSS-SECTIONAL STUDY OVER THREE YEARS

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A repeated cross-sectional assessment was conducted over three consecutive years to identify trends in anthropometric indices and nutritional status among preschool children in the Hung Ha district of Thai Binh province, Vietnam.

From 2021 to 2023, data were collected for three distinct samples with a total of 1002 children aged 24–72 months. For children younger than 60 months, the World Health Organization (WHO) 2006 criteria were used to determine the weight-for-age Z-score (WAZ), height-for-age Z-score (HAZ), BMI-for-age Z-score (BAZ), weight-for-height Z-score (WHZ). For children older than 60 age months, the 2007 WHO criteria were used to assess WAZ, HAZ, and BAZ. Significant improvements in weight, height, BMI, and anthropometric Z-scores were observed over the three-year period. While the rates of underweight and stunting declined, the prevalence of overweight and obesity rose significantly, indicating a double burden of malnutrition. This trend appears to originate from socioeconomic changes, increased caloric intake, and reduced physical activity.

The study underscores the need for comprehensive nutritional strategies to address both malnutrition forms, focusing on improving height for balanced and healthy growth among preschool children in rural areas of the Red River Delta.

Keywords: anthropometric indices, nutritional status, preschool children, cross-sectional study, socioeconomic changes, healthy nutrition strategies, rural area.

Anthropometric indices play an important role and are used as measures to assess children's physical growth and nutritional status (NS), providing insights into their health and overall development [1]. As the preschool age is crucial for growth and development and serves as the foundation for children's later progress, malnutrition in this early stage, whether undernutrition (underweight, stunted, and wasted) or overnutrition (overweight and obesity), detrimentally affects health and psychology in adulthood [2]. A number of studies

have indicated that malnourished children are at a higher risk of diminished physical health, and even obesity in adulthood, while overweight or obese children are more susceptible to early-onset puberty, bone diseases, high blood pressure, metabolic disorders, cancers, and obesity as adults [3, 4]. Therefore, it is essential to assess changes in NS trends and children's anthropometric characteristics during the preschool years to develop effective nutritional strategies at family, school, and national levels.

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Vietnam currently suffers from the double burden of malnutrition, a common nutritional problem in developing countries with the coexistence of both overnutrition and undernutrition [5]. The Red River Delta of Vietnam is a densely populated region with diverse economic contributions from agriculture, industry, and services. However, a disparity in nutritional status between urban and rural children still persists, with a higher prevalence of underweight and stunting in rural areas [6–8]. Hung Ha is a rural district located in the northwest of Thai Binh province, part of the northern Red River Delta, comprising 33 communes and 2 towns. Its economy is largely driven by agriculture, industry, and handicrafts, with a total production value of about VND 23 trillion in 2023, marking a 6 % increase over 2022 (ranking 3rd among 8 districts and cities)¹.

To date, research on NS and anthropometric characteristics in Vietnamese children primarily focuses on central cities or ethnic minorities [9, 10], resulting in a paucity of data on rural areas or those with moderate economic development. Recently, the NS of first-grade students in the Kien Xuong district of Thai Binh province was reported by Pham Quoc Hung [11] but this remained a cross-sectional study on a small sample size. Another longitudinal study by Nguyen Thi Nhan also examined the NS of preschool children in the Vu Xuong district of Thai Binh province, but the changes were observed over only a three-month period [12]. Therefore, this study **aims** to examine the changing trends in anthropometric characteristics and NS of preschool children in Hung Ha district, Thai Binh province over three years (2021–2023) using a large sample size ranging from 24 to 72 age months. The findings of this study may serve as the basis for developing and implementing targeted interventions to enhance the optimal development of preschool children in rural areas of the Red River Delta.

Materials and methods. This repeated cross-sectional study was carried out over three consecutive years from 2021 to 2023 in order to

assess trends in anthropometric indices and nutritional status (NS) among preschool children in Hung Ha district, Thai Binh province. The sampling method was cluster-based, representative, and random. Preschool children participating in the study were selected from 10 kindergartens in Hung Ha. All children from these schools were measured for height and weight on the 4th day of the 2nd week of December in 2021, 2022, and 2023, after obtaining written consent from parents or legal guardians.

Exclusion criteria included children with acute or chronic illnesses documented in medical records and under medical care at the time of collecting sample or those receiving treatment for lipid disorders or obesity. Children whose parents or legal guardians did not agree to participate were also excluded.

The anthropometric indices and NS of the children were analyzed and compared after randomly matching the data by age and sex, ensuring consistent sex ratios and age groups over the three years examined. After matching by sex and age, there was a total of 1002 children (aged 23.9–72.4 months, 54.5 % male) included in the final analysis.

Anthropometric measurements were conducted between 9:00 and 10:30 a.m. in a climate-controlled room. Children wore light clothing and were weighed and measured following standard procedures of the National Institute of Nutrition. Weight was measured using an electronic scale with a precision of 100 grams. Standing height was measured using a stadiometer with an accuracy of 0.1 cm.

For children younger than 60 months, the World Health Organization (WHO) 2006 criteria were used to determine the weight-for-age Z-score (WAZ), height-for-age Z-score (HAZ), BMI-for-age Z-score (BAZ), weight-for-height Z-score (WHZ) [13]. For children older than 60 age months, the 2007 WHO criteria were used to assess WAZ, HAZ, and BAZ [14]. These analyses were automatically computed by the WHO Anthro software (for children younger than 60 months) version 3.2.2 and AnthroPlus®

¹ The total production value of the whole district in 2023 is estimated to increase by 6.38 %. *Thaibinh Province Portal*, 2023. Available at: <https://s.net.vn/kinh-te-hung-ha> (April 12, 2024).

software (for children older than 60 months) version 1.0.4 (Geneva, Switzerland). Table 1 provides the cutoff points of anthropometric Z-scores for classification of children's nutritional status based on the WHO standards.

Statistical tests were conducted using SPSS version 16.0 (SPSS, Chicago, USA), and relevant graphs were generated using Excel. Quantitative variables were assessed for normality and expressed as mean \pm standard deviation if they were normally distributed or median (25th – 75th percentile) if not. The Student's t-test was employed to compare the distribution of two normally distributed groups,

and the Mann-Whitney U test was employed to compare the distribution of two non-normally distributed groups. Differences in proportions were analyzed using the Chi-square test or Fisher's exact test. A two-tailed p-value of less than 0.05 was considered statistically significant.

Results and discussion. Changes in anthropometric indices in preschool children from 2021 to 2023. Changes in weight, height, BMI, WAZ, HAZ, BAZ, and WHZ for male children over the three-year period from 2021 to 2023 are presented in Table 2 and Figure 1.

Table 1

Cut-offs for classification of nutritional status for preschool children according to WHO standards

Index	Value	Nutritional status
WAZ	< -3SD	Severe underweight
	< -2SD	Moderate underweight
	from -2SD to 2SD	Normal
	> 2SD	Overweight
	> 3SD	Obesity
HAZ	< -3SD	Severe stunting
	< -2SD	Moderate stunting
	from -2SD to 2SD	Normal
BAZ	< -3SD	Severe wasting
	< -2SD	Moderate wasting
	from -2SD to 2SD	Normal
	> 2SD	Overweight
	> 3SD	Obesity

Table 2

Changes in anthropometric indices among male preschoolers in Hung Ha from 2021 to 2023

Index	2021 (1)	2022 (2)	2023 (3)	$P_{(1)(2)}$	$P_{(2)(3)}$	$P_{(1)(3)}$
Age (months)	48.93 (36.93–60.46)	48.58 (36.03–60.9)	49.45 (36.63–61.0)	0.979 ^b	0.968 ^b	0.938 ^b
Weight (kg)	15.90 (13.50–18.0)	16.5 (14.0–19.0)	17.0 (15.0–19.5)	0.002 ^b	0.297 ^b	< 0.000 ^b
Height (cm)	101.0 (93.0–106.0)	104.5 (97.0–110.0)	103.0 (98.0–110.0)	< 0.000 ^b	0.430 ^b	0.001 ^b
BMI (kg/m ²)	15.71 (14.71–16.9)	15.50 (14.41–16.91)	16.01 (15.03–17.46)	0.487 ^b	0.011 ^b	0.055 ^b
WAZ	-0.25 \pm 1.08	0.30 \pm 1.03	0.40 \pm 1.11	< 0.000 ^a	0.360 ^a	< 0.000 ^a
HAZ	-0.69 \pm 1.42	0.24 \pm 0.99	0.06 \pm 1.25	< 0.000 ^a	0.120 ^a	< 0.000 ^a
WHZ	0.18 \pm 1.08	0.14 \pm 1.16	0.48 \pm 1.25	0.762 ^a	0.018 ^a	0.031 ^a
BAZ	0.27 \pm 1.10	0.17 \pm 1.29	0.52 \pm 1.25	0.422 ^a	0.009 ^a	0.044 ^a

Note: ^a Variables are expressed as mean \pm standard deviation; p-values were obtained from Student's t-test;

^b Variables are expressed as median (25th–75th percentile); p-values were obtained from the Mann – Whitney U-test.

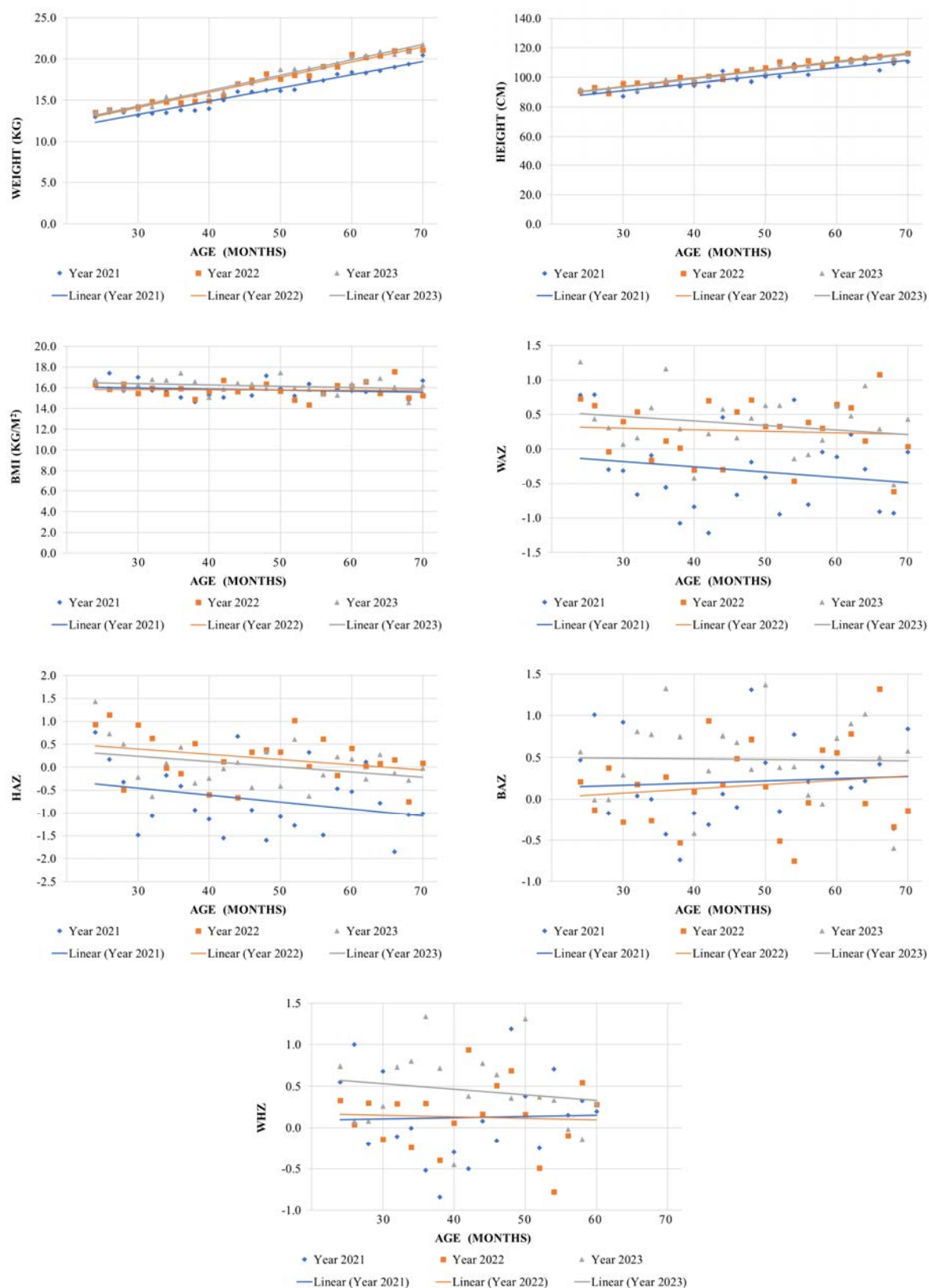


Figure 1. Changes in Weight, Height, BMI, WAZ, HAZ, BAZ, and WHZ by Age in Male Preschool Children in three survey years

According to Table 2 and Figure 1, the weight, height, and WAZ of male preschoolers in Hung Ha district were higher in 2022 than in 2021 (16.5 kg vs. 15.9 kg; 104.5 cm vs. 101.0 cm; 0.3 SD vs. -0.25 SD, respectively) but no significant difference in these indices between 2022 and 2023 was observed ($P > 0.05$). In contrast, WHZ and BAZ were statistically higher in 2023 than in 2022 and 2021 ($P < 0.05$). For the HAZ, this index was found to be significantly different among three years examined ($P > 0.05$) with the highest value detected in 2022 (0.24 SD) and the lowest in 2021 (-0.69 SD).

The changes in weight, height, BMI, WAZ, HAZ, BAZ, and WHZ indices in female children over the three years from 2021 to 2023 are presented in Table 3 and Figure 2.

Similar to the male children, there were significant increases in weight, height, WAZ, and HAZ from 2021 to 2022 among female children ($P < 0.05$) but not between 2022 and 2023 ($P > 0.05$). By contrast, the WHZ index of female preschoolers was significantly higher in 2023 in comparison to both 2021 and 2022, at 0.55 SD versus 0.17 SD and 0.15 SD, respectively ($P < 0.05$). Notably, BMI and BAZ did not exhibit significant differences across the three years in the female group ($P < 0.05$).

Changes in nutritional status. The prevalence of nutritional status among preschool children, classified by WAZ, HAZ, and BAZ indices, in the three study years is presented in Figures 3, 4, and 5, respectively.

In the present study, there has been a notable increase in the anthropometric indices of preschool children in Hung Ha district from 2021 to 2023. Interestingly, the survey time coincides with the coronavirus disease 2019 (COVID) pandemic and post-COVID periods providing evidence of shifts in the nutritional status of children during and after the wave of COVID-19 in Vietnam.

For boys, the average weight and height, along with their WAZ and HAZ, were the lowest in 2021. These measures showed a significant increase in 2022 and remained stable in 2023 indicating sustained improvement over the initial survey. The proportional growth in weight and height of boys from 2021 to 2022 resulted in no significant year-to-year differences in WHZ and BAZ. However, these two indices exhibited a significant increase from 2022 to 2023 suggesting that weight growth had surpassed height growth during the latter period. This trend can be visualized through the linear regression analyses of WHZ and BAZ depicted in Figure 1. When comparing the changes in weight, height, and BMI by age with the WHO sex-specific growth reference curves [13, 14], the data for 2021 showed that the height growth of preschool boys was still approaching below the Z-score = 0 curve, while the growth in weight and BMI generally fell within the Z-score = 0 threshold. By the years 2022 and 2023, all these curves have

Table 3

Changes in anthropometric indices of female preschool children in Hung Ha from 2021 to 2023

Index	2021 (1)	2022 (2)	2023 (3)	$P_{(1)-(2)}$	$P_{(2)-(3)}$	$P_{(1)-(3)}$
Age (months)	48.83 (36.13–60.68)	49.11 (36.13–60.5)	48.82 (35.37–61.05)	0.969 ^b	0.931 ^b	0.899 ^b
Weight (kg)	15.0 (13.1–16.8)	15.5 (14.0–19.0)	16.5 (15.0–18.35)	0.001 ^b	0.134 ^b	< 0.000 ^b
Height (cm)	97.0 (93.0–105.0)	103.0 (95.0–109.0)	103.0 (96.5–108.5)	< 0.000 ^b	0.982 ^b	< 0.000 ^b
BMI (kg/m ²)	15.46 (14.51–16.40)	15.47 (14.39–16.81)	15.70 (14.70–16.93)	0.973 ^b	0.141 ^b	0.109 ^b
WAZ	-0.40 ± 1.06	0.17 ± 0.97	0.33 ± 1.08	< 0.000 ^a	0.176 ^a	< 0.000 ^a
HAZ	-0.80 ± 1.43	0.12 ± 1.10	0.11 ± 1.29	< 0.000 ^a	0.934	< 0.000 ^a
WHZ	0.17 ± 1.14	0.15 ± 1.25	0.55 ± 1.21	0.930	0.018	0.016
BAZ	0.14 ± 1.11	0.11 ± 1.26	0.37 ± 1.24	0.823	0.063	0.081

Note: ^a Variables are expressed as mean ± standard deviation; p -values were obtained from Student's t -test;

^b Variables are expressed as median (25th–75th percentile); p -values were obtained from the Mann – Whitney U -test.

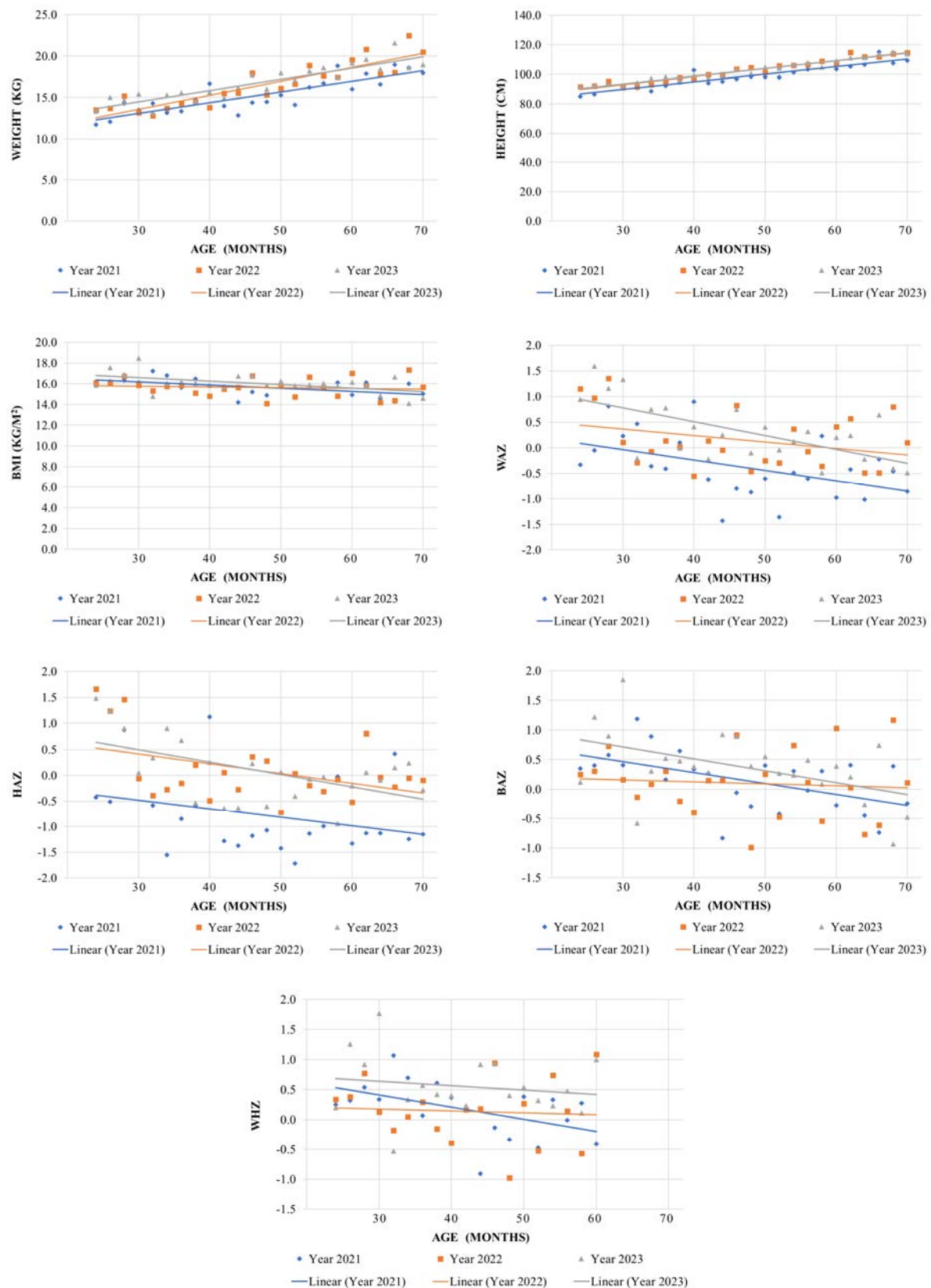


Figure 2. Changes in weight, height, BMI, WAZ, HAZ, BAZ, and WHZ by age in female children in three survey years

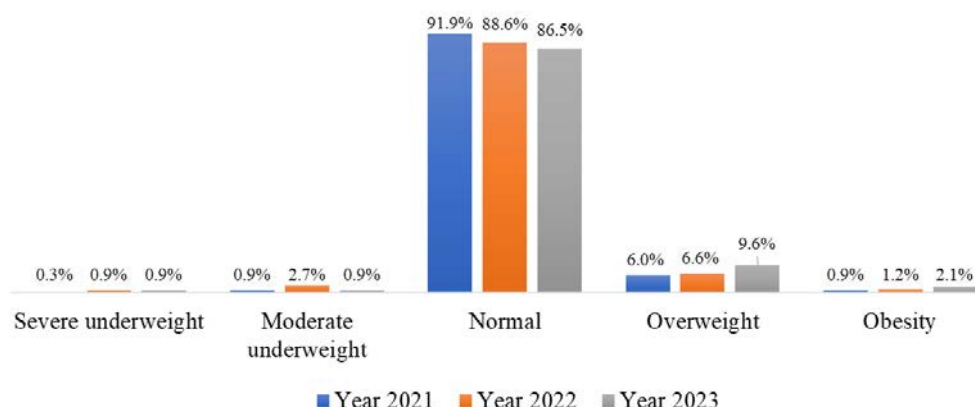


Figure 3. Nutritional status of children classified by WAZ

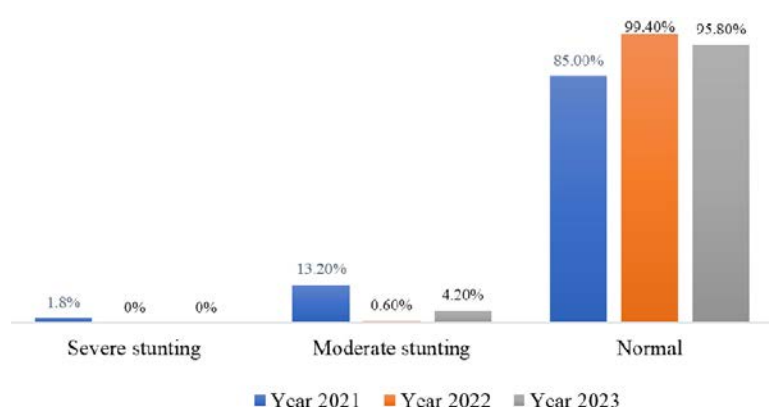


Figure 4. Nutritional status of children classified by HAZ

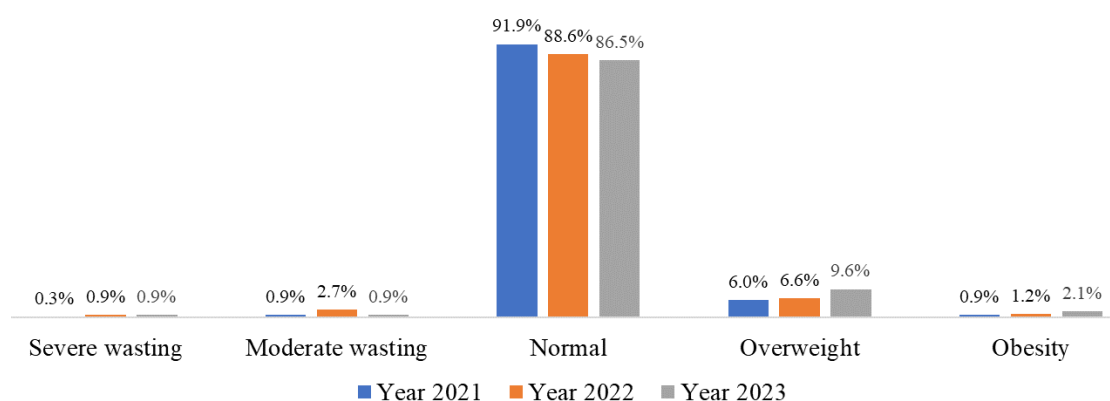


Figure 5. Nutritional status of children classified by BAZ

reached and even surpassed the $Z\text{-score} = 0$ threshold, reflecting an overall enhancement in growth patterns.

For girls, a significant increase in HAZ and BAZ in 2022 compared to 2021 resulted from corresponding improvements in height and weight of children during the same period.

Although there were no statistical differences in BMI and BAZ over the three examined years, the notably higher WHZ value year to year indicated a similar trend where weight growth exceeded height growth, albeit less pronounced than in boys. This phenomenon can be explained by the fact that boys eat fast

foods and consume sugar-sweetened drinks more often than girls leading to a higher caloric intake [15, 16]. When changes in weight, height, and BMI of female children by age (Figure 2) were compared to WHO growth standards, it was found that curves of height growth and weight growth in 2021 were still approaching below the Z-score = 0 curve, but by 2022 and 2023, all three curves reached or even surpassed the Z-score = 0 threshold [13, 14]. These findings suggest a consistent improvement in the care and nutritional practices for preschool girls in the region. Thus, over the three consecutive years of assessment for both sexes, there was a consistent trend of growth in both weight and height. However, weight growth was more pronounced compared to improvements in children's height, which may reflect the early impact of the nutrition transition resulting from increased caloric intake in their diet [17].

Regarding nutritional status, stunting was the most prevalent form of malnutrition in 2021 (15.5 %) and 2023 (4.2 %), whereas wasting was the most common form in 2022 (3.6 %). Among the three years of assessment, malnutrition rates varied inconsistently across forms. While underweight and stunting rates in 2022 decreased compared to 2021 but rose again in 2023, the wasting rate in 2022 (3.6 %) was higher than in 2021 (1.6 %) and 2023 (1.8 %). This result possibly arises from the interruption of schooling in Vietnamese children during the COVID-19 pandemic. Since all kindergartens were closed in late 2021 and 2022 to implement the social distancing directive, children had to stay at home for a long time and thus did not have any chance to lose weight due to various factors including incorrect diets, increased screen time, decreased physical activity, family and individual stress [18]. During this period of lockdown imposed by the outbreak, many Vietnamese parents were under the misconception that feeding their children more would make them healthy, boost their immunity, and reduce the impact of

the disease, thus focusing on providing their children with high-energy meals. As a result, children were less likely to suffer from under-nutrition but were at risk of overweight and obesity. In line with this hypothesis, studies in several populations have reported an increase in weight gain among children and adolescents during the COVID-19 pandemic compared with the rate before the pandemic [19–21]. In addition, as the stunting rate in children is assessed based on the height-for-age Z-score, which reflects long-term nutritional deficits, the high prevalence of stunting in this study indicates that children's growth remains affected by socioeconomic constraints; therefore, chronic malnutrition has cumulative effects on this growth². The consistently low wasting rate, in contrast, does not reflect an improvement in socioeconomic conditions or long-term nutritional changes, since this form of malnutrition is assessed based on BAZ, which represents short-term, acute nutritional deficiencies².

In contrast to the decrease in the rate of child malnutrition, this study demonstrates a continuous upward trend in the rates of overweight and obesity among preschool children in Thai Binh in recent years. In 2023, overweight and obesity rates classified by BAZ were 9.6 % and 2.1 %, respectively, significantly higher than the corresponding rates in both 2022 and 2021 ($P < 0.05$). According to another study on preschool children of Thai Binh province, the prevalence of underweight stunting, wasting, overweight/obesity in children under 5 of was 12.8 %, 24.3 %, 3.1 %, and 2.5 %, respectively [12]. Compared with our results, the malnutrition rates of children from 2021 to 2023 have decreased remarkably in all three forms, but overweight and obesity rates have also increased. While in 2021 and 2022, the increased rate of overweight and obesity could partly be explained by a sedentary lifestyle and changes in food habits during the COVID-19 pandemic [18], these forms of overnutrition continued to rise in 2023 despite schools reopened and chil-

² Sommerfelt A.E., Stewart M.K. Children's nutritional status. Maryland, USA, Macro International Publ., 1994, 47 p.

dren no longer being limited in their play and interaction spaces at this time. This phenomenon can be ascribed to a combination of reasons, in which increased consumption of processed foods, along with the habit of using electronic devices for entertainment (which indirectly reduces physical activity), has contributed largely to the increased risk of obesity in this age group. As indicated by previous studies, Vietnamese children nowadays, particularly in Delta Red River regions, have been affected by the obesogenic environment, which promotes high-energy food consumption while reducing physical activity, thereby increasing sedentary behaviors [22]. In addition, the recent changes in children's nutritional status also resulted from the active implementation of malnutrition prevention programs as well as the improvement of socioeconomic conditions enabling children to be better nourished than before [10].

The present study has some strong points. It is the first to analyze the trends in anthropometric changes in Vietnamese preschool children in a rural area over three consecutive years, a period with numerous changes from both socioeconomic conditions and the influence of the COVID-19 pandemic. As each survey period involves a new sample, the study design avoids bias that might result from participants dropping out in longitudinal studies, and the results are more generalizable to represent the entire population. Despite that, the inability to track changes within individual children over time is a major limitation of this study. Longitudinal studies that follow children over time in order to elucidate the trajectory of growth patterns and the impact of various interventions therefore are suggested.

Thus, this study reaffirms that Vietnamese rural areas continue to bear the double burden of malnutrition. Although there were significant improvements in child nutrition and care, the growing rates of overweight and obesity are alarming. Insights from the present study underscore the need for policy makers to revise current nutritional guidelines and promote community-specific health programs aimed at eradicating malnutrition in all its forms. Nutritional intervention programs for young children must prioritize enhancing height and reducing stunting, which remains a critical issue in child nutrition in Vietnam.

Conclusion. Data from the three-year survey revealed significant improvements in weight, height, WAZ, and HAZ among Vietnamese rural preschool children in 2022 compared to 2021. In boys, there were also significant increases in BMI, BAZ, and WHZ indices in 2023 than in 2022. Regarding nutritional status, stunting remained the most prevalent form of malnutrition among preschool children. From 2021 to 2023, undernutrition rates changed inconsistently across all forms, while rates of overweight and obesity exhibited a constant increase. These changes likely reflect progress in child nutrition and care practices as well as the influence of the COVID-19 pandemic. Nutritional policies, particularly those focused on the prevention of stunting and overnutrition should be developed and implemented to ensure the healthy development of children.

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Competing interests. The authors declare no competing interests.

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