Current Height Status and the Discrepancy from Government Growth Targets for 2026 and 2036 Among 9–12-Year-Old Children in Mae Hong Son, Thailand

Siwaporn Mahathamnuchock[1]*

[1] Mae Hong Son College, Chiang Mai Rajabhat University, Thailand
* Siwaporn Mahathamnuchock, corresponding author. Email: siwaporn_mah@cmru.ac.th
Submitted: 30 December 2024. Accepted: 2 June 2025. Published: 25 June 2025
Volume 34, 2026. pp. 344–361. http://doi.org/10.25133/JPSSv342026.018

Abstract

Childhood height is a critical indicator of nutritional status and overall health. This cross-sectional study examined factors associated with current and projected future height among school-aged children (9–12 years old) in Mae Hong Son, Thailand. A total of 175 participants were selected from 823 eligible children using systematic sampling across two semi-urban subdistricts. Descriptive statistics summarized sociodemographic and health-related characteristics. One-sample *t*-tests were used to assess differences between participants' heights and national reference standards, as well as government target heights for 2026 and 2036. Multiple linear regression identified early childhood development (β = 0.16, p = .039) and sufficient food and nutrition (β = 0.17, p = .022) as significant predictors of current height. Among males, projected height shortfalls ranged from 2.25 to 5.69 cm in 2026 and 7.25 to 10.69 cm in 2036, with most age groups showing statistically significant differences. Among females, the 2026 data showed mixed results, with some age groups exceeding targets, while the 2036 projections revealed consistent shortfalls, with the most significant deficit of -6.69 cm at age 9. These findings reveal age- and gender-specific disparities in meeting national growth targets. Comprehensive, multisectoral interventions addressing nutrition and early childhood development are crucial for enhancing child growth outcomes in rural Thailand.

Keywords

Childhood height; early childhood development; growth predictors; height discrepancies; nutritional status; rural Thailand

Introduction

Thailand prioritizes the nutritional status and growth of its population through policies targeting children and adolescents, as well as national policies related to height and nutrition. In 2021, the government introduced the indicator "percentage of children/adolescents who are proportionately tall," segmented by age groups (0–2, 3–5, 6–14, and 15–18 years), to measure the proportion of children achieving heights aligned with national standards (Department of Health, 2023). National targets for 2026 aim for average heights of 180 cm for men and 167 cm for women (Thai Health Promotion Foundation, 2016). To support these goals, the Ministry of Public Health updated growth standards in 2021—the first revision in 26 years—to enhance assessment accuracy and align with policies promoting optimal growth.

Despite many adolescents in Mae Hong Son, particularly in Mae La Noi District, meeting or exceeding height standards, the average height for both sexes remains below national levels. This has prompted further investigation into contributing factors (Ministry of Public Health, 2022). The province also reports a stunting prevalence of 19.4% among children aged 0–5 and about 11% among those aged 6–14 (Mae Hong Son Provincial Public Health Office, 2021), underscoring persistent nutritional and health disparities.

Similar trends are observed across Southeast Asia, where seven countries report stunting rates that exceed the global average. Timor-Leste has the highest prevalence (48.8%), followed by Indonesia, Laos, Cambodia, the Philippines, Myanmar, and Vietnam, with rates ranging from 22% to 32% (UNICEF et al., 2021). These disparities warrant deeper investigation. While children in developed countries often reach their full growth potential, research shows that those in developing countries can also achieve significant improvements given appropriate nutrition, care, and support (de Onis et al., 2019).

Multiple studies emphasize the roles of genetics, nutrition, physical activity, and environmental conditions in influencing height (Ghosh et al., 2024; Ritthimon et al., 2023; Saavedra & Prentice, 2023; Wungrath et al., 2022). For instance, adequate nutrition promotes growth (Saavedra & Prentice, 2023); regular physical activity supports height gain during skeletal development (Ghosh et al., 2024); and mental well-being, along with strong social support systems, enhances growth outcomes (Kim et al., 2018; Ritthimon et al., 2023).

In northern Thailand, cultural dietary practices—particularly a reliance on carbohydrate-rich foods—contribute to persistent nutritional disparities. In Mae Hong Son, these challenges are compounded by the mountainous terrain and dispersed rural communities, which limit access to healthcare, especially in remote districts like Sop Moei and Khun Yuam, where only one doctor serves every 10,000 people, and travel to district hospitals is often difficult (Mae Hong Son Provincial Statistical Office, 2022). Comparable access issues are reported in the border areas of Laos and Myanmar due to similar geography and limited health workforce capacity (UNICEF, 2021).

A recent Thai study found moderate dietary diversity among children, characterized by a high consumption of grains and tubers but a low intake of nuts, seeds, and pulses. No significant gender or age differences were observed. Interestingly, children not involved in family meal decisions were less likely to have inadequate dietary diversity (AOR = 0.55, 95% CI [0.31–0.95]) (Siviroj et al., 2024). Additionally, Thai children face a double burden of malnutrition, with persistent micronutrient deficiencies (e.g., iron, vitamin A, and vitamin D) alongside

rising rates of overweight and obesity. A national survey revealed increasing obesity, especially among children aged 7–12.9 years, with variations by age, sex, and location. Widespread deficiencies in calcium, iron, zinc, and vitamins persist, with vitamin D insufficiency being particularly prevalent in urban areas and among females (World Health Organization [WHO], 2024a).

This study applies the Social Determinants of Health (SDH) framework to examine the lower height status observed in Mae Hong Son, particularly among younger children (Centers for Disease Control and Prevention [CDC], 2024; WHO, 2024a). The SDH framework acknowledges how factors such as income, education, housing, healthcare access, environmental conditions, and social support interact to shape health outcomes. Mae Hong Son's persistently high poverty rate—ranking the highest nationally for more than a decade (2006–2016, excluding 2015, and again in 2023), with a rate of 12.49% compared to 3.64% in the Northern region and 8.61% nationwide—likely limits access to nutritious food, healthcare, and sanitation (Office of the National Economic and Social Development Council, 2024).

Failure to achieve optimal height during childhood has long-term consequences, including reduced cognitive and educational performance, lower adult income, increased risks of chronic diseases such as cardiovascular disease and diabetes, and the intergenerational transmission of poor health outcomes (UNICEF, 2021; WHO, 2024b). While most studies report on current height disparities or stunting prevalence, few have projected children's future growth potential in relation to national targets. This study contributes by estimating probable final heights for children in Mae Hong Son and comparing them to Thailand's 2026 and 2036 goals, offering a forward-looking perspective on growth inequality.

Methodology

This study employed a quantitative approach to evaluate the height status and projections of children aged 9–12 years in Mae Hong Son, Thailand, and to examine deviations from government growth targets. Participants were recruited from two semi-urban subdistricts, Pha Bong and Pang Moo, Mueang Mae Hong Son district. These two semi-urban subdistricts were purposively selected due to their consistently high prevalence of stunting among school-aged children, which aligns with the study's aim to explore height discrepancies in vulnerable populations. According to the Ministry of Public Health (2020), 42.3% of children were reported to be below the standard average height. The study population, comprising school-age children as of March 2023, consisted of 823 individuals (Mae Hong Son Primary Educational Service Area Office 1, 2023).

The required sample size was calculated using G*Power version 3.1.9.7 for a two-tailed *t*-test comparing independent means, with an assumed medium effect size (Cohen's $d = 0.5$), a significance level of $\alpha = .05$, and a power $(1 - \beta)$ of 0.80. The calculation yielded a minimum of 128 participants. Therefore, a sample size of 175 participants was recruited, which was deemed sufficient for the analysis. Participants were selected using systematic sampling to ensure the representativeness of the sample. The final sample consisted of 91 males and 84 females, drawn from two semi-urban subdistricts—Pha Bong and Pang Moo—known for their high prevalence of stunting among school-aged children. Inclusion criteria were as follows: (1) children aged 9–12 years, (2) currently enrolled in formal education, and (3) capable of understanding the purpose of the study. The sole exclusion criterion was participants who chose to withdraw from the research. Although the total population was 823

children, a representative sample was selected to maintain feasibility while ensuring adequate statistical power.

Materials and methods

Data were collected between March and September 2023 through a self-administered survey, with some participants receiving assistance from their guardians to complete the questionnaire at home. The survey instrument consisted of two main sections:

1) Demographic Characteristics: This section, designed based on the SDH framework, captured information on early childhood development, nutrition, physical activity, mental health, and social support among children. To facilitate self-administration, this section included seven dichotomous survey items addressing the following topics: gender, birth weight, early childhood development, the sufficiency of food and nutrition, mental health status, social support promoting growth and height, and number of meals per day (< 3, = 3, or > 3), for all of the key factors—early childhood development, food and nutrition sufficiency, mental health status, and social support promoting growth and height—were measured using a self-administered questionnaire completed by the children's guardians.

   The questionnaire included simple, structured items designed for ease of understanding and response. Early childhood development was assessed by asking whether the child had reached key developmental milestones by the age of five to six. Food and nutrition sufficiency was evaluated based on the guardian's perception of whether the child consistently received enough food and a balanced diet. Mental health status was assessed using a single-item question that asked whether the child had exhibited signs of emotional or behavioral difficulties in the past six months. Social support was assessed by asking whether the child regularly received encouragement and assistance from family members or community figures to support their physical growth and development. For physical activity, this study adopted a threshold of 15–30 minutes per day or 150 minutes per week. This threshold was based on standard practices in Thai school-based programs, where limited time is allocated for physical activity due to curriculum constraints and other contextual factors. Aligning with these prevalent conditions allowed for a more accurate assessment of children's actual physical activity levels in the study area (Widyastari et al., 2022).

   Data were obtained from both children and their guardians. Parental confirmation was required for birth weight, developmental milestones, and household factors to enhance accuracy.

2) Anthropometric Measurements: This section recorded participants' current weight and height, which were measured during school health screenings in August 2023. Projected heights were also estimated for the years 2026 and 2036 for males and females aged 9 to 12 years.

   The questionnaire underwent content validity testing using the Index of Item-Objective Congruence (IOC), with three experts in the field reviewing the items.

Items scoring above 0.6 on the IOC were deemed acceptable. Reliability testing yielded a Cronbach's alpha coefficient of 0.88, indicating high internal consistency.

Projected expected final height

The expected final height was calculated using the growth curve comparison method (Mlakar et al., 2023) based on each participant's current height, age, sex, and remaining growth potential. The current height was plotted on Thai national growth charts (Department of Health, 2021), and growth velocity percentiles were used to estimate the remaining height gain. The formula applied was: Expected Height = Current Height + Remaining Growth Potential (based on sex- and age-specific growth velocity percentile). This method represents a visual extrapolation of individual growth trajectories along standard curves rather than a regression or mathematical model.

Ethical considerations

This research was also approved by the Chiang Mai Rajabhat University Institutional Review Board (IRBCMRU) under approval number 2022/349.28.12, COA No. 349/2022. Written informed consent was obtained from parents or guardians, and verbal assent was obtained from participating children. Participant confidentiality was maintained by assigning coded identification numbers; no personal identifiers were included in data files or reports.

Statistical analysis

Descriptive statistics were used to analyze the sociodemographic data, which were presented as frequencies, percentages, means, medians, maximum and minimum values, and standard deviations. To evaluate differences in height, comparisons were made between the current height and the Thai standard height, as well as between the expected future height and the government's target heights for 2026 and 2036.

For inferential statistics, the data distribution was assessed for normality to ensure that statistical assumptions were met. A one-sample *t*-test was then used to compare the mean differences between (1) the current height and the Thai standard height, and (2) the expected future height and the government's target heights for 2026 and 2036. These comparisons were conducted separately for males and females across each age group (9–12 years).

Data examination was conducted before analysis to identify potential outliers and ensure that key assumptions—linearity, homoscedasticity, independence of errors, normality, and independence of independent variables—were met. This process confirmed the suitability of the data for statistical analysis. Multiple linear regression analysis using the enter method was conducted to examine the following associations:

1) Factors associated with current height: The independent variables included birth weight, early childhood development, number of meals per day, sufficiency of food and nutrition, daily physical activity, mental health status, and social support that promotes growth and height. The dependent variable was the children's current height.

2) Factors associated with expected final future height: The independent variables included birth weight, current height, early childhood development, number of meals per day, sufficiency of food and nutrition, daily physical activity, mental health status, and social support promoting growth and height. The dependent variable was the children's expected final future height.

Results

As shown in Table 1, the sample consisted of 52.0% males. Birth weights of ≥ 2.5 kg were reported for 67.1% of male participants and 69.1% of female participants. Normal early childhood development was observed in 98.9% of males and 89.0% of females. Regarding dietary habits, 78.0% of males and 86.9% of females consumed three meals per day. Adequate food and nutrition were reported by 90.1% of males and 71.4% of females. However, a notable proportion failed to meet the recommended physical activity levels (15–30 minutes daily or 150 minutes weekly), with 51.7% of males and 60.7% of females falling short of the target. Mental health outcomes were predominantly positive, with 91.2% of males and 95.2% of females reporting good mental health. Lastly, social support promoting growth and height was reported by 92.3% of males and 91.7% of females.

Table 1: Sociodemographic Characteristics of Participants

Variable	Male		Female	
	n	%	*n*	%
Gender	91	52.0	84	48.0
Birth weight (kg)				
≤ 2.5	30	32.9	26	30.9
≥ 2.5	61	67.1	58	69.1
Early childhood development				
Normal development	90	98.9	81	89.0
Developmental lag	1	1.1	3	11.0
Meals per day				
< 3	18	19.8	4	4.8
3	71	78.0	73	86.9
> 3	2	2.2	7	8.3
Sufficient food and nutrition				
Yes	82	90.1	60	71.4
No	17	9.9	16	28.6
15–30 minutes of physical activity per day, 150 minutes per week				
Yes	44	48.3	33	39.3
No	47	51.7	51	60.7
Mental health status				
Good	83	91.2	80	95.2
Fair	8	8.8	4	4.8
Social support promotes growth and height				
Yes	84	92.3	77	91.7
No	7	7.7	7	8.3

The study revealed that among males, 38.46% were aged 11 years, and 26.37% were aged 12 years. Among females, 45.24% were aged 11 years, and 30.95% were aged 10 years. The mean current weight for 11-year-old males was 38.97 kg (Median = 35.00, SD = 12.22), while 9-year-

old males averaged 35.77 kg (Median = 37.00, SD = 9.48). For females, the mean weight of 12-year-olds was 43.93 kg (Median = 39.50, SD = 12.22), and for 9-year-olds, it was 29.88 kg (Median = 34.00, SD = 8.45). In terms of current height, 12-year-old males had an average height of 146.25 cm (Median = 147.50, SD = 9.00), compared to 138.31 cm (Median = 138.00, SD = 9.09) for 9-year-old males. Among females, 12-year-olds had an average height of 152.33 cm (Median = 149.50, SD = 7.42), while 9-year-olds averaged 137.38 cm (Median = 138.50, SD = 10.23). Regarding expected future height, 12-year-old males were projected to reach the highest average height of 172.75 cm (Median = 172.00, SD = 10.42), while 10-year-olds had the lowest projection of 167.58 cm (Median = 170.00, SD = 7.19). For females, the highest expected future height was observed in 12-year-olds at 171.33 cm (Median = 164.00, SD = 10.61), while the lowest projection was for 9-year-olds at 161.63 cm (Median = 160.00, SD = 3.54), as summarized in Table 2.

Table 2: Current Height and Projected Future Height for Males and Females Aged 9–12 Years

Gender	Age	*n (%)*	Current weight		Current height		Expected future height	
			$\bar{x}$ *(SD)*	*Min–Max (MDN)*	$\bar{x}$ *(SD)*	*Min–Max (MDN)*	$\bar{x}$ *(SD)*	*Min–Max (MDN)*
Male	9	13 (14.29)	35.77 (9.48)	24–51 (37.00)	138.31 (9.09)	120–154 (138.00)	169.31 (6.85)	160–180 (170.00)
	10	19 (20.88)	35.79 (12.39)	22–75 (32.00)	138.89 (10.32)	120–171 (137.00)	167.58 (7.19)	169–180 (170.00)
	11	35 (38.46)	38.97 (12.22)	21–68 (35.00)	145.46 (8.50)	128–164 (146.00)	168.20 (8.77)	159–190 (165.00)
	12	24 (26.37)	36.37 (8.21)	25–59 (34.50)	146.25 (9.00)	131–164 (147.50)	172.75 (10.42)	160–192 (172.00)
Female	9	8 (9.52)	29.88 (8.45)	21–43 (34.00)	137.38 (10.23)	120–153 (138.50)	161.63 (3.54)	160–170 (160.00)
	10	26 (30.95)	33.88 (7.82)	25–54 (34.00)	142.04 (6.31)	128–152 (142.00)	165.00 (6.31)	159–180 (165.00)
	11	38 (45.24)	40.79 (11.23)	26–85 (36.00)	149.08 (6.28)	136–163 (149.00)	166.76 (6.59)	159–180 (166.00)
	12	12 (14.29)	43.93 (12.22)	36–68 (39.50)	152.33 (7.42)	145–163 (149.50)	171.33 (10.61)	160–190 (164.00)

Note: Male (n = 91), Female (n = 84)

Regarding the Thai standard height for males aged 9 to 12 years, significant differences were found at the .05 level between current heights and the Thai standard heights. The most significant mean difference was observed in 9-year-old males (15.31 cm), followed by 11-year-olds (13.46 cm), with the least significant difference noted in 12-year-olds (8.25 cm). For females, all age groups showed statistically significant differences in height. The most significant mean difference was recorded in 9-year-old females (14.37 cm), whereas the least significant difference was found in 12-year-olds (8.67 cm), as summarized in Table 3.

Table 3: Mean Difference Between Current Height and Thai Standard Height for Males and Females aged 9–12 years

Gender	Age	Thai Standard Height (cm.)	*MD*	*t*	*df*	*p*
Male	9	123	15.31	6.07	12	.000*
	10	127	11.90	5.02	18	.000*
	11	132	13.46	9.37	34	.000*
	12	138	8.25	4.49	23	.000*
Female	9	123	14.37	3.98	7	.005*
	10	129	13.04	10.54	25	.000*
	11	136	13.08	12.84	37	.000*
	12	142	8.67	5.43	11	.000*

Note: Male (n = 91), Female (n = 84). Significant difference from Thai standard height at p < .05. cm = centimeter; MD = mean difference; t = t-statistic; df = degrees of freedom

Table 4: Mean Difference Between Expected Final Future Height for Males and Females Aged 9–12 Years and the Government Target Future Height for 2026 and 2036

Gender	Age	2026 Target future height[a] (cm.)	*MD*	*t*	*df*	*p*	2036 Target future height[a] (cm.)	*MD*	*t*	*df*	*p*
Male	9	175	-5.69	-3.00	12	.011*	180	-10.69	-5.63	12	.000*
	10	175	-7.42	-4.50	18	.000*	180	-12.42	-7.53	18	.000*
	11	175	-6.80	-4.59	34	.000*	180	-11.80	-7.96	34	.000*
	12	175	-2.25	-1.06	23	.301	180	-7.25	-3.41	23	.002*
Female	9	162	-0.30	-0.38	7	.773	170	-6.69	-8.38	7	.000*
	10	162	2.57	3.00	25	.017*	170	-4.28	-5.00	25	.000*
	11	162	4.45	4.76	37	.000*	170	-3.03	-3.24	37	.004*
	12	162	4.75	1.84	11	.092	170	-1.26	-3.25	11	.233*

Note: [a] Target heights for Thai males and females in 2026 and 2036, according to the Ministry of Public Health's 15-year target (The Coverage, 2021), indicate a significant difference from the Thai standard height at $p < .05$; cm = centimeter; MD = mean difference; t = t-statistic; df = degrees of freedom; A positive mean difference indicates that the current height exceeds the reference; a negative mean difference indicates it falls below.

Table 4 presents the mean differences (MD) between the expected final future heights of males and females aged 9–12 years and the government's target future heights for the years 2026 and 2036. For males, the mean differences showed significant shortfalls across most age groups in both 2026 and 2036. Specifically, the MD ranged from -5.69 cm at age 9 to -2.25 cm at age 12 in 2026 and from -10.69 cm at age 9 to -7.25 cm at age 12 in 2036. The results were statistically significant ($p < .001$) for all age groups except age 12 in 2026 ($p = .301$). For females, the MDs showed mixed trends. In 2026, positive MD values were observed in females aged 10 to 12, indicating that they were expected to exceed the government's target heights. With the most significant positive difference at age 12 (+ 4.75 cm, $p = .092$). However, in 2036, females showed negative MD values across all ages, with the most pronounced shortfall of -6.69 cm at age 9 ($p < .001$). These results highlight evolving patterns of gender- and age-specific disparities in meeting the government's target heights, underlining the need for tailored interventions to address both current and future growth challenges.

As shown in Table 5, significant predictors of height for males and females aged 9–12 years were early childhood development ($\beta = 0.16$, $F = 2.08$, $p = .039$) and sufficient food and nutrition ($\beta = 0.17$, $F = 2.31$, $p = .022$). Other variables, including birth weight, meals per day, physical activity, mental health status, and social support, did not significantly predict height in this age group.

The multiple linear regression analysis indicated that current height could be modeled as **Height = 133.00 + 9.45 (early childhood development) + 3.17 (sufficient food and nutrition).**

This model demonstrated moderate predictive accuracy, with an R-squared value of 0.82 and an adjusted R-squared value of 0.44.

Table 5: Multiple Linear Regression Analysis Assessing the Association Between Sociodemographic Factors and Height for Males and Females Aged 9–12 Years

Variable	*b*	*β*	*F*	*p*
Birth weight (kg)	0.25	0.01	0.17	.869
Early childhood development	9.45	0.16	2.08	.039*
Meals per day	-0.63	-0.04	-0.48	.630
Sufficient food and nutrition	3.17	0.17	2.31	.022*
Physical activity per day	2.45	0.14	1.83	.069
Mental health status	-2.53	-0.07	-0.96	.339
Social support promotes growth and height	2.16	0.07	0.86	.393

Note: Constant = 133.00; $R^2 = 0.08$; Adjusted $R^2 = 0.04$; $F = 2.14$; $p = .043$; Significant predictors of height at $p < .05$; b = unstandardized regression coefficient; β = standardized regression coefficient (beta); F = F-statistic

The only significant predictor of expected final future height for males and females aged 9–12 years was current height ($\beta = 0.27$, $F = 3.58$, $p < .001$). Other factors, such as birth weight, early childhood development, meals per day, sufficient food and nutrition, daily physical activity, mental health status, and social support, did not significantly predict the expected final future height.

The multiple linear regression model revealed that the expected final future height could be expressed as follows: **Expected final future height = 130.40 + 0.25 (Current height).**

The current height was the only variable significantly associated with the expected final future height. This model demonstrated moderate predictive accuracy, with an R-squared of 0.10 and an adjusted R-squared of 0.06 (Table 6).

Table 6: Multiple Linear Regression Analysis Assessing the Association Between Sociodemographic Factors and Expected Final Future Height for Males and Females Aged 9–12 Years

Variable	*b*	*β*	*F*	*p*
Birth weight (kg)	0.74	0.04	0.56	.578
Current height (cm)	0.25	0.27	3.58	.000*
Early childhood development	1.19	0.02	0.28	.779
Meals per day	-0.51	-0.03	-0.44	.664
Sufficient food and nutrition	0.83	0.05	0.66	.510
Physical activity per day	1.44	0.09	1.19	.236
Mental health status	0.89	0.03	0.37	.709
Social support promotes growth and height	0.53	.018	0.23	.817

Note: Constant = 130.40; $R^2 = 0.10$; adjusted $R^2 = 0.06$; $F = 2.38$; $p = .019$; significant predictor of expected final future height ($p < .05$); b = unstandardized regression coefficient; β = standardized regression coefficient (beta); F = F-statistic

Discussion

This section explores the key findings of the study, focusing on how early childhood development and nutrition factors influence current and projected height among children in Mae Hong Son.

Influence of early childhood development and nutrition on current height among children aged 9–12 years

This study highlights the critical role of early childhood development and adequate nutrition as the primary determinants of current height in children aged 9–12. These results are supported by statistical evidence, reinforcing the urgency of prioritizing interventions during the 0–6-year age window. Early childhood is a foundational period for physical, cognitive, emotional, and social growth, all of which shape long-term health and development (Likhar et al., 2022; UNICEF, 2023).

In this study, most participants demonstrated normal early development—98.9% of males and 89% of females—emphasizing the importance of early stimulation and care (CDC, 2023). Additionally, the majority were born with healthy birth weights (≥ 2.5 kg), reflecting generally favorable prenatal conditions. However, gender disparities in reported nutritional adequacy were evident: 90.1% of males reported sufficient nutrition compared to only 71.4% of females. These patterns may stem from caregiving practices during early childhood, which often persist into adolescence and predict later health and behavioral outcomes (Guyon-Harris et al., 2021).

In many middle-income countries, such as Thailand, Pakistan, and Bangladesh, females under five have been shown to receive less nutrition than males (Channa et al., 2024; Khalil et al., 2020; Rahman et al., 2021). In contrast, studies from low-income countries, such as Ethiopia,

reveal higher undernutrition rates among males, which are linked to factors including birth size, breastfeeding, maternal education, and rural residence (Sahiledengle et al., 2023).

Social and cultural norms further shape gendered nutritional access. In South Asia, females with many older brothers are at greater risk of malnutrition due to household food allocation preferences (Hatlebakk, 2012). Broader regional research also shows that gender biases in food distribution often favor males (Sen & Hook, 2012). In Thailand, these disparities continue into middle childhood (ages 6–12), where parents may enforce more restrictive feeding practices on females, limiting their access to nutrient-rich foods. In contrast, males often enjoy greater autonomy in food choices, which may lead to richer nutritional intake (Yamborisut et al., 2018). Moreover, societal norms tend to be more accepting of overweight males, contributing to differences in dietary patterns and body image pressures (Pawloski et al., 2023).

Despite living in the same sociocultural environment, boys in this study reported significantly higher levels of nutritional adequacy. This disparity may reflect persistent gender norms in rural northern Thailand that prioritize male children in household food distribution and meal planning. Cultural preferences, as noted in previous studies (Sen & Hook, 2012; Yamborisut et al., 2018), may grant boys greater autonomy in food choices, resulting in richer diets, especially during later childhood.

These findings highlight how early development and gendered nutrition practices intersect, reinforcing the need for culturally sensitive, gender-equitable interventions to support optimal child growth.

Discrepancies between expected and government target heights

A key finding of this research is the significant gap between the expected final future heights of children and the government's target heights for 2026 and 2036, particularly for males. The results revealed that the expected future heights for males consistently fall short of the government's target heights, especially for the 2036 projections (The Coverage, 2021), with projected shortfalls in male height ranging from -7.25 to -10.69 cm below government targets. In contrast, the shortfalls among females are smaller, ranging from −1.36 to −6.68 cm. While females aged 10–12 are projected to meet the 2026 targets, this should not be interpreted as parity with male benchmarks. Instead, it indicates that current growth trajectories for females may align more closely with national targets, possibly due to more stable nutrition in late childhood. Nonetheless, both sexes require targeted support to ensure equitable opportunities for healthy development.

These height deficits reflect broader structural inequalities in health and socioeconomic conditions, especially in rural and underserved regions. Data from Thailand's Sixth National Health Examination Survey (NHES VI) show that provinces like Mae Hong Son consistently report lower height-for-age scores compared to urban areas (National Health Security Office, 2021). International studies' findings support this pattern. Wake et al. (2023) reported strong associations between childhood stunting and factors such as low parental education, limited household income, and poor access to clean water, which are common conditions in highland communities of northern Thailand. Such socioeconomic disadvantages, compounded by ethnic marginalization and limited public investment, likely hinder children's growth potential.

Interestingly, despite reporting higher levels of nutritional adequacy and physical activity, boys exhibited greater discrepancies from target height benchmarks. This may be due to the higher metabolic and nutritional demands of male adolescent growth spurts, which are challenging to meet in low-resource environments (Wake et al., 2023). Even relatively better nutrition may still be insufficient to meet growth needs. Cultural and structural barriers may also contribute to the fact that males are more affected. Males may have higher nutritional demands during adolescence, which are challenging to meet in resource-limited settings. In contrast, females may benefit from more consistent nutritional support during later childhood, enabling them to achieve height benchmarks. Failing to meet these growth standards has long-term consequences, including reduced educational performance, lower productivity, and an increased risk of chronic diseases (Acoba, 2024).

Addressing these disparities requires early-life nutrition interventions, routine school-based growth monitoring, and gender-responsive programming. Multisectoral policies that enhance maternal education, alleviate food insecurity, and strengthen healthcare infrastructure in remote areas are essential. Without targeted action, achieving national height goals will remain unattainable for marginalized children. Given the dominant influence of early childhood development and nutrition on height outcomes, these factors should be prioritized in public health interventions. While physical activity and mental health are essential for overall well-being, neither of these factors significantly predicted height in this study. Interventions should be evidence-driven, with targeted investment in early-life nutrition and development support to close the growth gap in remote Thai provinces.

Implications from the perspective of social determinants of health

From a SDH perspective, multiple interrelated factors influence child growth in Mae Hong Son. Educational attainment among parents plays a crucial role, as lower levels of education may limit understanding of proper nutrition and child health practices. Household income is another critical factor, with high poverty rates reported at 12.49% in the province, restricting access to nutritious food, healthcare, and other essential resources (Office of the National Economic and Social Development Council, 2024).

Access to health services is also constrained due to Mae Hong Son's remote geography and underdeveloped infrastructure, resulting in delays in routine growth monitoring and nutrition interventions. The physical environment further compounds these challenges; inadequate sanitation and substandard housing increase children's exposure to infections, which can directly impair growth. Finally, although social support levels were generally reported as high, gaps may remain in the availability and consistency of community-level support systems, such as childcare, parental leave, or access to community health workers.

While the study found that current height was the only significant predictor of expected future height, the negative mean differences suggest that children are not on track to meet national health and growth targets. Among females, similar but slightly less pronounced gaps were observed, with notable discrepancies between the expected future heights and government targets particularly evident in the 10 to 12-year-old age groups. These findings underscore the urgency of implementing growth-promoting interventions, particularly for children at key developmental stages, to ensure that they meet the desired height standards and reduce the risk of growth delays that could have long-term health consequences (Ministry of Public Health, 2021).

Strengths and limitations

This study offers essential contributions by focusing on a vulnerable and underserved population in a remote border area of Thailand. Assessing height in relation to national growth targets provides timely and relevant insights into the challenges faced by children in marginalized rural settings. The use of school-based data collection ensured standardized anthropometric measurements, enhancing the reliability and validity of the findings. Furthermore, the identification of gender-specific discrepancies contributes to public health planning by informing the design of targeted interventions.

However, several limitations must be acknowledged. First, the study's cross-sectional design limits the ability to infer causality between SDH and growth outcomes. Longitudinal studies are necessary to capture growth trajectories more effectively and to understand the temporal relationships between contributing factors. Second, the reliance on self-administered questionnaires—particularly for variables such as food sufficiency and physical activity—introduces the possibility of response bias. Additionally, detailed data on dietary intake, physical activity frequency and intensity, and pubertal status were not collected, which may have provided a more comprehensive understanding of growth influences. Finally, the projection of expected height was based on modeling assumptions that may not fully capture local genetic, environmental, or policy-related influences.

Despite these limitations, the study offers valuable insights into the factors that influence child growth in a rural population. It emphasizes the challenges ahead for future interventions aimed at improving health outcomes in similarly underserved settings.

Conclusion

This study provides critical evidence on the height status of school-aged children in Mae Hong Son, Thailand, revealing a substantial gap between their projected final heights and the national growth targets for 2026 and 2036. Early childhood development and adequate nutrition emerged as key predictors of current height, while current height significantly predicted future expected height. These findings emphasize the foundational role of early-life interventions in shaping long-term growth trajectories.

However, many children, particularly males, were projected to fall significantly short of national growth targets, with discrepancies reaching over 11 cm in some cases. This underscores a pressing need for integrated public health strategies that address not only dietary quantity and quality but also promote regular physical activity and tackle broader social determinants of health.

Reducing child height disparities requires coordinated, multisectoral efforts. The following recommendations propose integrated actions across schools, communities, and healthcare systems to improve height literacy, promote healthy behaviors, and support early detection and intervention.

Bridging these disparities requires early, gender-sensitive, and context-specific interventions that go beyond individual behavior change to address systemic inequities in healthcare access, food security, education, and poverty. The application of the SDH framework in this study

underscores the need for comprehensive strategies that consider the interrelated nature of biological, social, economic, and environmental factors influencing growth.

Policy and practice recommendations to promote optimal child growth

The recommended strategies are as follows:

- The government should integrate height literacy, a comprehensive understanding of factors related to growth, such as nutrition, growth milestones, and access to healthcare, into the school curriculum, particularly in early childhood education.
- To enhance the effectiveness of interventions, local government sectors should have clearly defined roles, with health departments leading technical support, education sectors integrating growth promotion in schools, and community agencies supporting family engagement. Coordinated efforts will ensure accountability and sustainability.
- Health-promoting hospitals, Subdistrict Administrative Organizations, and Provincial Administrative Organizations should implement targeted interventions to promote health behaviors that support optimal height growth. These interventions should include creating environments conducive to physical activity, with adequate spaces and equipment, ensuring access to balanced nutrition, and fostering awareness of the importance of regular growth monitoring.
- Schools and healthcare settings should play a proactive role in providing access to accurate information related to growth and healthcare services. Should focus on regularly monitoring children's height against standardized growth charts, identifying deviations, and addressing height growth concerns promptly through evidence-based strategies.

Future research should employ longitudinal designs to investigate the temporal dynamics of height development and explore the regional, cultural, and socioeconomic factors that drive growth disparities. By addressing these factors comprehensively, Thailand can make significant progress toward achieving equitable health outcomes for all children, regardless of their geographical location.

Acknowledgments

I would like to acknowledge the support of the Thailand Science Research and Innovation (TSRI) and Chiang Mai Rajabhat University for their funding, provided through the grant for this research.

References

Acoba, E. F. (2024). Social support and mental health: The mediating role of perceived stress. *Frontiers in Psychology, 15*, Article 1330720. https://doi.org/10.3389/fpsyg.2024.1330720

Centers for Disease Control and Prevention (CDC). (2023). *Watch me! Celebrating milestones and sharing concerns*. https://www.cdc.gov/ncbddd/watchmetraining/docs/watch-me-training-print.pdf

Centers for Disease Control and Prevention (CDC). (2024, January 17). *Social Determinants of Health (SDOH).* https://www.cdc.gov/about/priorities/why-is-addressing-sdoh-important.html

Channa, M. J., Wassan, S. M., Inayatullah, Dharani, S. D., Rahoojo, M. I., & Hussain, T. (2024). Child malnutrition in Pakistan: Prevalence and risk factors of malnutrition in children under 5 years. *Journal of Xi'an Shiyou University, Natural Science Edition, 20*(4), 704–708. https://www.xisdxjxsu.asia/viewarticle.php?aid=3231

de Onis, M., Borghi, E., Arimond, M., Webb, P., Croft, T., Saha, K., De-Regil, L. M., Thuita, F., Heidkamp, R., Krasevec, J., Hayashi, C., & Flores-Ayala, R. (2019). Prevalence thresholds for wasting, overweight and stunting in children under 5 years. *Public Health Nutrition, 22*(1), 175–179. https://doi.org/10.1017/S1368980018002434

Department of Health. (2021, March 4). *Khumukan chai kenkh ang ing kan charoen toepto khong dek ayu 6–19 pi* [Guide for using growth reference criteria for children aged 6–19 years]. Ministry of Public Health. https://multimedia.anamai.moph.go.th/associates/guide-using-the-growth-criteria-for-children-ages6_19/

Department of Health. (2023). *Raai laai lae tua chiwat fao rawang thaang phochanakaan pracham pii ngoppramaan Pho.Sor. 2566* [Details of nutrition surveillance indicators for the fiscal year 2023]. Ministry of Public Health. https://nutrition2.anamai.moph.go.th/web-upload/6x22caac0452648c8dd1f534819ba2f16c/m_magazine/37955/4092/file_download/333c82b2cf9ecc6845280d29d24f530b.pdf

Ghosh, D., Khan, I. A., Yadav, S., & Bandyopadhyay, S. (2024). The impact of early childhood nutrition on long-term health outcomes: A prospective cohort study. *Journal of Population Therapeutics and Clinical Pharmacology, 31*(3), 317–324. https://doi.org/10.53555/jptcp.v31i3.4789

Guyon-Harris, K. L., Humphreys, K. L., Miron, D., Tibu, F., Fox, N. A., Nelson, C. A., & Zeanah, C. H. (2021). Early caregiving quality predicts consistency of competent functioning from middle childhood to adolescence following early psychosocial deprivation. *Development and Psychopathology, 33*(1), 18–28. https://doi.org/10.1017/S0954579419001500

Hatlebakk, M. (2012). *Malnutrition in South Asia: Poverty, diet or lack of female empowerment?* (CMI Working Paper No. 2012:4). Chr. Michelsen Institute. https://www.cmi.no/publications/file/4406-malnutrition-in-south-asia-poverty.pdf

Khalil, A., Bashir, S., & Al Mostafa, M. Y. (2020). Demographic profile associated with malnutrition. *Pakistan BioMedical Journal, 3*(2). https://doi.org/10.52229/pbmj.v3i2.11

Kim, S., Lee, H. E., & Yang, H. R. (2018). Current status of nutritional support for hospitalized children: a nationwide hospital-based survey in South Korea. *Nutrition Research and Practice, 12*(3), 215–221. https://doi.org/10.4162/nrp.2018.12.3.215

Likhar, A., Baghel, P., & Patil, M. (2022, September 23). *Early childhood development and social determinants*. Cureus, *14*(9), Article e29500. https://doi.org/10.7759/cureus.29500

Mae Hong Son Primary Educational Service Area Office 1. (2023). *Sathiti thang kan sueksa pi kan sueksa 2566*) [Educational statistics for the 2023 academic year] Office of the Basic Education Commission.

Mae Hong Son Provincial Public Health Office. (2021). *Khumu kae kan serua kan pen phl haeng ruprang læa kan phatthana dek luknoi nai changwat mæ hong son* [Request for cooperation in solving the problems of early childhood children in Mae Hong Son Province]. Ministry of Public Health. http://www.maehongsonlocal.go.th/system_files/309/acb991e1951b538c88a83acf00871508.pdf

Mae Hong Son Provincial Statistical Office. (2022). *Rai-ngan sathiti changwat Mae Hong Son pho. so. 2565* [Mae Hong Son Statistical Report: 2022]. National Statistical Office. https://maehson.nso.go.th/images/ebook/ProvinceReport2565.pdf

Ministry of Public Health. (2020). *Percentage of children aged 6–14 years with normal height for age and average height at age 12*. https://youthlink.gbdi.cloud/am/dataset/hdc_moph_nutrition_57a93cide28682b2718e6cc82b8dbb3e00f2e28e

Ministry of Public Health. (2021). *Tua chiwat mattran borikan satharanasuk* [Standard indicators for public health services]. https://hdc.moph.go.th/center/public/standard-subcatalog/67f8b1657bc8c796274fb9b6ad5a701d

Ministry of Public Health. (2022). *Percentage of children aged 6–14 years with normal height for age and average height at age 12*. Health Data Center (HDC), Ministry of Public Health, Thailand.

https://hdc.moph.go.th/center/public/standard-report-detail/e28682b2718e6cc82b8dbb3e00f2e28e

Mlakar, M., Gradišek, A., Luštrek, M., Jurak, G., Sorić, M., Leskošek, B., & Starc, G. (2023). Adult height prediction using the growth curve comparison method. *PLOS ONE, 18*(2), Article e0281960. https://doi.org/10.1371/journal.pone.0281960

National Health Security Office. (2021). *Thailand Health Profile Report 2021*. Ministry of Public Health. https://www.hsri.or.th/printed-matter/399

Office of the National Economic and Social Development Council. (2024, September). *Rai-ngan khwam yak chon læa khwam laek lai nai Prathet Thai, pho. so. 2566* [Poverty and Inequality Report 2023]. https://www.nesdc.go.th/ewt_dl_link.php?nid=15744

Pawloski, L. R., Harnirattisai, T., Vuthiarpa, S., Curtin, K. M., & Nguyen, J. T. (2023). Gender-based determinants of obesity among Thai adolescent boys and girls. *Adolescents, 3*(3), 457–466. https://doi.org/10.3390/adolescents3030032

Rahman, T., Al Mamun, M. A., Ghosh, S., Ahmed, S., Akhtaruzzaman, M., Munni, F. K., & Chowdhury, S. (2021). Nutritional status of under-five children among urban slum dwellers in Dhaka City, Bangladesh. *Indian Journal of Public Health Research & Development, 12*(1), 484–494. https://doi.org/10.37506/ijphrd.v12i1.13895

Ritthimon, W., Thongprachum, A., & Wungrath, J. (2023). A qualitative exploration of exclusive breastfeeding practices among Karen ethnicity mothers in Northern Thailand's remote rural areas. *Kesmas*, *18*(3), 152–159. https://doi.org/10.21109/kesmas.v18i3.6662

Saavedra, J. M., & Prentice, A. M. (2023). Nutrition in school-age children: A rationale for revisiting priorities. *Nutrition Reviews, 81*(7), 823–843. https://doi.org/10.1093/nutrit/nuac089

Sahiledengle, B., Mwanri, L., Blumenberg, C., & Agho, K. E. (2023). Gender-specific disaggregated analysis of childhood undernutrition in Ethiopia: Evidence from 2000–2016 nationwide survey. *BMC Public Health, 23*(1), Article 2040. https://doi.org/10.1186/s12889-023-16907-x

Sen, S., & Hook, M. (2012, June 27). *Gender-inclusive nutrition activities in South Asia: Mapping report*. South Asia Region - Social Development Unit, The World Bank. https://documents1.worldbank.org/curated/en/513231468101988482/pdf/710890ESW0P1270SDS0FINAL0ClearedMap.pdf

Siviroj, P., Wungrath, J., & Ongprasert, K. (2024). Associated factors of dietary patterns among adolescents in the rural northern region of Thailand: A community-based cross-sectional study. *Healthcare, 12*(12), Article 1215. https://doi.org/10.3390/healthcare12121215

Thai Health Promotion Foundation. (2016, May 10). *Serim phochna kan phưa dek Thai sung som suan* [Boosting nutrition for well-proportioned Thai children]. https://www.thaihealth.or.th/?p=258329

The Coverage. (2021, March 4). *Set ap khwam sung khon Thai him Sath. tang pea xik 15 pi khang hrua chay 180 sm. - hying 170 sm.* [New 'Thai Height' setup, Ministry of Public Health sets target for the next 15 years: Male 180 cm – Female 170 cm]. https://www.thecoverage.info/news/content/1197

UNICEF. (2021, October). *Southeast Asia regional report on maternal nutrition and complementary feeding*. https://www.unicef.org/eap/media/9466/file/Maternal%20Nutrition%20and%20Complementary%20Feeding%20Regional%20Report.pdf

UNICEF. (2023). *Early childhood development: For every child, early moments matter.* https://www.unicef.org/early-childhood-development

UNICEF, World Health Organization, & World Bank Group. (2021, May 6). *Levels and trends in child malnutrition: UNICEF/WHO/World Bank Group joint child malnutrition estimates (2021 edition)*. World Health Organization. https://data.unicef.org/resources/jme-report-2021/

Wake, S. K., Zewotir, T., Lulu, K., & Fissuh, Y. H. (2023, April 20). *Longitudinal trends and determinants of stunting among children aged 1–15 years*. Archives of Public Health, 81(1), Article 60. https://doi.org/10.1186/s13690-023-01090-7

Widyastari, D. A., Saonuam, P., Pongpradit, K., Wongsingha, N., Choolers, P., Kesaro, S., Thangchan, W., Pongpaopattanakul, P., Phankasem, K., Musor, M., Autchaworaphong, P., Muensakda, P., Chaiprasit, K., Yousomboon, C., Mansing, W., Aunampai, A., Nilwatta, N., Iamyam, W., Rasri, N., & Katewongsa, P. (2022). Results from the Thailand 2022 report card on physical activity

for children and youth. *Journal of Exercise Science & Fitness, 20*(4), 276–282. https://doi.org/10.1016/j.jesf.2022.06.002

World Health Organization (WHO). (2024a, January 18). *Operational framework for monitoring social determinants of health equity*. https://www.who.int/publications/i/item/9789240088320

World Health Organization (WHO). (2024b, June 26). *Physical activity*. https://www.who.int/news-room/fact-sheets/detail/physical-activity

Wungrath, J., Chanwikrai, Y., Khumai, N., & Sutan, P. (2022). Perception towards food choice among low-income factory worker parents of pre-school children in Northern Thailand: A qualitative study. *Malaysian Journal of Public Health Medicine*, 22(3), 98–106. https://doi.org/10.37268/mjphm/vol.22/no.3/art.1682

Yamborisut, U., Visetchart, P., Thasanasuwan, W., Srichan, W., & Unjana, R. (2018). Parental feeding practice is associated with child's body mass index in Thai school-aged children: A case study in Don Tum district, Nakhon Pathom, Thailand. *Journal of Health Research, 32*(1), 82–94. https://doi.org/10.1108/JHR-11-2017-010