ORIGINAL ARTICLE

Smart Medical Journal

Smart Medical Journal (SMedJour) April 2024, Vol. 7, No.1, pp: 29 - 36
DOI: https://doi.org/10.13057/smj.v7i1.79718
E-ISSN: 2621-0916 | P-ISSN: 2621-1408

Low Birth Weight as Predictor of Underweight and Stunting Among Female Students Aged 6-9 Years: an Observational Study in Surakarta

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Recived: 24/10/2023
Accepted: 16/02/2024
Published: 24/07/2024

ABSTRACT

Introduction: Undernutrition remains a leading cause of premature mortality among children in developing countries. Previous studies discussed that the risk of undernutrition elevated with child's age, stressing the need to address undernutrition in older children. Maternal factors also caused undernutrition through intergenerational transmission. However, data related to nutritional status of female children age >5 years in Indonesia are lacking. This study aimed to elucidate determinants associated with nutritional status among primary school girls in Surakarta.

Methods: This was an observational, cross-sectional study. A total of 61 female students aged 6-9 years from Nur Hidayah Primary School Surakarta participated in this study. Data were collected through online questionnaire filled by parents who were directed to follow the procedures of anthropometric measurement at home. Z-score was calculated using WHO AnthroPlus software. Nutritional status of children was measured in weight-for-age and height-for-age. Statistical analyses were performed using Spearman's correlation and backward linear regression. Variables with p<0.05 from the final model were considered as the determinants.

Results: Among study participants, 4.9% were underweight and 9.9% were stunted. Our study found one common determinant of nutritional status by weight-for-age and height-for-age, namely birth weight (p=0.027 and p=0.011 respectively). Maternal height was, in particular, associated with nutritional status by height-for-age (p=0.001).

Conclusion: Birth weight was significantly associated with nutritional status by weight-for-age and height-for-age, while maternal height was significantly correlated with only nutritional status by height-for-age. Nutrition programs for female students such as school lunch and multivitamin supplementation could be implemented to prevent the intergenerational effects of stunting and underweight.

Keywords: low birth weight; nutritional status; school-age children; stunting; underweight

INTRODUCTION

Undernutrition prevails to be an urging health concern among children in developing countries [1]. Undernutrition could be identified by plotting weight and height measurements against a standardized growth chart [2-4], resulting in three widely recognized indicators: stunting (height-for-age below the normal value), underweight (weight-for-age below the normal value), and wasted (weight-for-height below the normal value). Each indicator depicts a unique purpose, in which stunting indicates chronic undernutrition, wasting indicates acute undernutrition, while underweight depicts both acute (wasting) and chronic (stunting) undernutrition in childhood [5-7].

In 2011, the worldwide incidence of stunting, underweight, and wasting among children under five was estimated as 164.8 million, 100.7 million, and 51.5 million, respectively [8]. A recent global report in 2020 predicted that 149.2 million children under five suffered from stunting and 45.4 million suffered from wasting. However, the report did not provide updated data regarding the incidence of underweight [1]. In Indonesia, data regarding the incidence of undernutrition were updated once in 5 years and reported as prevalence. The latest national health survey in 2018 indicated that the prevalence of stunting, underweight, and wasting were 30.8%, 17.7%, and 10.2%, respectively [9].

Published estimates indicate undernutrition as a leading cause of premature mortality among children. Approximately 45% of mortality among children under five are related to undernutrition [1]. The global mortality associated with stunting, underweight, and wasting were around 1.017 million, 999,000, and 875,000, respectively [8].

Undernutrition was established as a result of multifactorial cause, mainly poor health quality during pre and postnatal [10]. Maternal factors primarily contributed to child undernutrition through intergenerational transmission. Studies indicated that short-stature mothers were more likely to deliver stunted children, who eventually grew up to be short mothers and continued to the intergenerational cycle [11]. Child's age was also associated with undernutrition [12]. Previous studies have discussed that the risk of undernutrition significantly elevated with child's age [5, 7, 13]. It could be inferred that the incidence of undernutrition did not reduce with age and stressed the need to address undernutrition in older children.

To date, intervention programs were mostly focused on early-age children and failed to address school-age children. Nutrition strategies focusing on female students should be initiated. However, lack of current reports on the undernutrition in female children may limit this effort. Data related to determinants of nutritional status among female, school-age children in Indonesia are lacking. The purpose of this study was to elucidate determinants associated with nutritional status by weight-for-age and height-for-age among primary school female children in Surakarta.

METHOD

Study design and subjects

Our study implemented an observational, cross-sectional research design. The study was conducted from April to May 2022 in Surakarta, a city in Central Java. The sample size was estimated using the Lemeshow formula for cross-sectional study with confidence level of 95% (Z=1.96), absolute precision of 10% (d=0,1), and proportions of stunting and underweight [14]. Based on the latest national health survey, the prevalence of stunting and underweight in Indonesia was 19.3% and 13.8% respectively [9]. We found the highest calculated sample size was from stunting (59 subjects).

We used purposive sampling method to select the study subjects. A total of 61 female students from Nur Hidayah Primary School participated in this study based on the inclusion criteria: female students aged 6-10 years old. Students with physical deformity were excluded. Before participating, parents signed an online informed consent form. The research protocol has been approved by the Health Research Ethics Committee Faculty of Medicine Universitas Sebelas Maret No. 39/UN27.06.11/KEP/EC/2022.

Data collection and analysis

Data were collected through online questionnaire. Information regarding the study was provided before parents signed the informed consent form. Socio-demographics, socioeconomics, children's medical history, as well as children's and parents' anthropometric data were obtained from parents. Parents were also informed and encouraged to follow the standard procedures of anthropometric measurement at home. The procedures directed were as follow: children were weighted twice using a digital scale, with minimal clothes, and without shoes. The average value was reported as weight in kg. As for height, children and parents were measured twice using a microtoise and without shoes. The average value was reported as height in cm.

Z-score from anthropometric data was generated using WHO AnthroPlus software. Nutritional status of children was determined by two indices: 1) Weight for Age Z-score (WAZ) and 2) Height for Age Z-score (HAZ). According to the national guideline, WAZ classifications were underweight (-3 SD to <-2 SD), normal (-2 SD to 1 SD), and at risk of overweight (> 1 SD). HAZ classifications were severely stunted (<-3 SD), stunted (-3 SD to <-2 SD), and normal (-2 SD to 3 SD) [2].

Statistical analyses were performed using SPSS version 25 (IBM, SPSS Inc.). Normality of the data were tested using Kolmogorov-Smirnov. Descriptive statistics were performed to explain characteristics of the study subjects. Continuous data were presented as median (min-max) since normality test showed skewed data. Categorical data were presented as frequency and percentage. Correlation among variables were tested using Spearman's Rank test. Variables with p <0.25 were included in the multivariate analysis using linear regression backward method. Variables with p<0.05 from multivariate analysis were concluded as the determinants in our study.

RESULT

Baseline Characteristics of Study Subjects

Table 1 shows baseline characteristics of subjects with a total of 61 female students aged 6-9 years. Children's weight was between 16.4 and 57.6 kg, while the height was between 80 and 150 cm. WAZ value ranged from -2.68 to 4.40. HAZ value varied greatly from -7.68 to 4.13. In this study, 4.9% of female students aged 6-9 years were classified as underweight and 9.9% were stunted.

Factors Associated with Nutritional Status of Female Students aged 6-9 Years

Table 2 displays bivariate correlation of factors associated with nutritional status. Nutritional status by WAZ showed a significant positive correlation with birth weight (r=0.341, p<0.05). Meanwhile, nutritional status by HAZ showed a significant positive correlation with birth weight (r=0.311, p<0.05), mother's education (r=0.265, p<0.05), and mother's height (r=0.342, p<0.05).

Variables related to nutritional status by HAZ with p <0.25 were included in a backward linear regression test. The analysis resulted in the final model as shown in Table 3. Our study found that birth weight and mother's height were associated with nutritional status by HAZ. Mother's height had the strongest positive association with nutritional status by HAZ (r=0.404) followed by birth weight (r=0.265). It could be inferred that children with maternal height >150 cm and birth weight >2500 g were associated with better nutritional status as indicated by the higher HAZ value.

Table 1. Baseline Characteristics of Subjects

Variable	Median (min - max)	n (%)
Age (years)		
6		1 (1.6)
7	8 (6 – 9)	18 (29.5)
8		36 (59)
9		6 (9.8)
Weight (kg)	25 (16.4 – 57.6)	-
Height (cm)	123 (80 – 150)	-
Nutritional status WAZ		
Underweight	-0.1 (-2.68 – 4.40)	3 (4.9)
Normal		40 (65.6)
At risk of overweight		18 (29.5)
Nutritional status HAZ		
Severely stunted	-0.59 (-7.68 – 4.13)	2 (3.3)
Stunted		4 (6.6)
Normal		55 (90.2)
Father’s occupation		
Unemployed	-	0 (0)
Private sector		50 (82)
Public sector		11 (18)
Mother’s occupation		
Unemployed	-	8 (13.1)
Private sector		35 (57.4)
Public sector		18 (29.5)
Parental income		
< Minimum wage	-	2 (3.3)
≥ Minimum wage		59 (96.7)
Total		61 (100)

Note: continuous data presented as median (min-max) since normality test showed skewed data

Table 2. Spearman’s Correlation of Factors Associated with Nutritional Status

	WAZ (n=61)	HAZ (n=61)
Birth weight	r = 0.341 *p* = 0.007*	r = 0.311 *p* = 0.015*
Birth length	r = 0.50 *p* = 0.704	r = 0.099 *p* = 0.446
Exclusive breastfeeding	r = - 0.25 *p* = 0.848	r = - 0.209 *p* = 0.105
Complementary feeding	r = - 0.198 *p* = 0.126	r = - 0.183 *p* = 0.157
Infection in the past 6 months	r = 0.074 *p* = 0.569	r = - 0.130 *p* = 0.319
Mother’s education	r = 0.226 *p* = 0.080	r = 0.265 *p* = 0.039*
Father’s education	r = 0.136 *p* = 0.297	r = 0.113 *p* = 0.388
Parental income	r = 0.152 *p* = 0.243	r = 0.031 *p* = 0.810
Mother’s height	r = 0.241 *p* = 0.062	r = 0.342 *p* = 0.007*
Father’s height	r = 0.097 *p* = 0.458	r = 0.086 *p* = 0.510

*level of significance $p<0.05$

Table 3. HAZ Final Model of Multivariate Analysis

Variables	β	r	*p*
(Constant)	-8.583		<0.001
Birth weight	1.492	0.265	0.027*
Mother's height	2.739	0.404	0.001*

Note:
Final model's *p-value* ANOVA and adjusted R square are (*p*=<0.001; adjusted R2=28.6%)
*level of significance *p*<0.05

Table 4 shows the final model of the backward linear regression test for nutritional status by WAZ. Variables with p <0.25 were included in this analysis. Our study found that birth weight was associated with nutritional status by WAZ (r=0.322). It could be inferred that children with birth weight >2500 g were more likely to have better nutritional status by WAZ in primary school.

Table 4. WAZ Final Model of Multivariate Analysis

Variable	β	r	*p*
(Constant)	-3.364		0.014
Birth weight	1.797	0.322	0.011*

Note:
Final model's *p-value* ANOVA and adjusted R square are (*p*=<0.05; adjusted R2=8.9%)
*level of significance *p*<0.05

DISCUSSION

This study found sufficient number of underweight and stunted among female students aged 6-9 years in Surakarta. The proportions were below the national prevalence of underweight and stunting [9]. This might be explained by the household wealth in our study. Most of the children's parents worked in private sector and earned more than the minimum wage (IDR 2,034,810 in 2022). Parental income might influence availability of food and diet habit, thus affecting nutritional status of children [15]. A worldwide study among 35 low- and middle-income countries showed that the prevalence of underweight and stunting was significantly lower in richer households [16].

One common determinant of nutritional status by HAZ and WAZ that we found in this study was birth weight, meaning that children with low birth weight were significantly associated with stunting and underweight. This was in line with previous evidence in Bangladesh, India, and Pakistan which indicated that low birth weight was a strong determinant of stunting and underweight [5, 17, 18]. Another study in Malawi elaborated the risk of being stunted (57%) and underweight (15%) during childhood were significantly higher in children with low birth weight compared to those who were born with normal weight, after adjusting for other risk factors (child health, household environment, health services, etc.) [19].

Studies among Indonesian population also yielded similar result in which birth weight was associated with the incidence of stunting and underweight [7, 10, 20]. The plausible explanation for this association could be that children with low birth weight were more susceptible to infections including respiratory infections and diarrhea. In addition, they were at a higher risk of complications (e.g. loss of appetite, anemia, jaundice, chronic lung disorders, fatigue and sleep apnea) compared to normal birth weight children and ultimately led to undernutrition [17].

Our study also found that mother's education and mother's height were associated with stunting. Demographic studies among low- and middle-income countries found evidence that shorter maternal height was a determinant of stunting [16, 21, 22]. Short mothers (<150 cm) were at a higher risk of having stunted children by 2.5 times compared with normal-height mothers (>160 cm). It was indicated that a

1 cm increased of maternal height could significantly reduce the risk of stunting by 1% [11]. In line with the worldwide evidence, studies in Indonesia also concluded that maternal height <150 cm has been associated with poor linear growth in children [21, 23, 24].

The underlying biological mechanism might be that short-stature mothers were associated with low health quality and limited nutrients supply to the fetus, causing intrauterine growth restriction, low birth weight, and growth failure in children. This suggests an intergenerational transmission from mothers' faulty health status to their offsprings' linear growth [11, 16, 22].

The adjusted R2 value from the final model in Table 3 was 28.6%, which indicated that the ability of mother's height and birth weight to explain nutritional status by HAZ is 28.6%. While in Table 4, birth weight could explain 8.9% of nutritional status by WAZ. Hence, nutritional status by HAZ and WAZ might also be explained by other variables outside of this study. It has been established from previous studies that children's height was associated with consumption of milk and/or milk products and hand washing practice with soap [25], access to health care, health infrastructure [21], and number of antenatal care visit [11]. More evidence indicated that children's height and weight was associated with maternal mid-upper arm circumference [23], urban-rural status, and maternal BMI [16].

However, we did not find significant correlation among birth length, exclusive breastfeeding, complementary feeding, infection, father's education, father's height, and parental income with nutritional status. In line with our result, previous cohort studies in 7 low- and middle-income countries did not find effects of diarrhea or respiratory infections on child growth [26]. Moreover, a comprehensive review study found limited evidence on recent infection (e.g. diarrhea and respiratory infection) as determinant of stunting in Indonesia. The result indicated that the strength of the relationship was weak compared to study in Ethiopia [21]. Contrary with our finding, In Ethiopia, infection in the past 2 weeks were associated with the incidence of underweight in children aged 6-12 years, but not stunting [25]. The differences with our study could be attributed by the duration of recent infection. In our study, we used infection in the past 6 months while in the Ethiopian study was in the past 2 weeks.

A primary limitation of this study was possible risk of bias due to the self-reported nature of our online questionnaire, including the anthropometric data. Another limitation was regarding our study design. Associations between variables should be interpreted carefully since cross-sectional studies are unable to infer causation. Last, our study was unable to include food intake data and cultural determinants of stunting such as food taboo. Nevertheless, despite these limitations, our study elucidates factors associated with nutritional status by WAZ and HAZ which provides novel contribution to underweight and stunting issues among Indonesian school-age children.

Recommended Strategies and Interventions

The key point is to ensure sustainable interventions. Nutrition programs targeted specifically for female students such as school lunches and multivitamin supplementation could be vital strategies to prevent short-stature mothers, which is a risk factor for delivering undernutrition children. Social media campaign to promote the importance of both linear growth and appropriate weight during childhood could also be included in the strategies. These might prevent the intergenerational effects of stunting and underweight.

Although it was not discussed in the study, we also found 29.5% children who were at risk of overweight. The school lunch program, assisted by dietitians, could address both the under and over nutrition issue by providing nutrient-dense food.

CONCLUSION

In this study, 4.9% female students aged 6-9 years were underweight and 9.9% were stunted. We found one common determinant of nutritional status by HAZ and WAZ, namely birth weight. In particular, maternal height was associated with nutritional status by HAZ. This study adds theoretical findings related to underweight and stunting among Indonesian school-age children.

ACKNOWLEDGEMENTS

We would like to thank Universitas Sebelas Maret for funding this research with research number: 254/UN27.22/PT.01.03/2022. We would also like to thank study subjects for participating in this study.

CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

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