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ASSOCIATION BETWEEN INFANT SEX AND BIRTH WEIGHT WITH STUNTING

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Abstract

Stunting remains a pressing global health issue, particularly in low- and middle-income countries, where early-life risk factors significantly influence growth trajectories. Among these, infant sex and birth weight are frequently examined as predictors of impaired linear growth. This study aimed to analyze the association between infant sex and birth weight with the incidence of stunting among children aged 6–59 months. A cross-sectional study was conducted involving 127 children aged 6–59 months from "x" village at north sumatera. Stunting was defined according to the World Health Organization growth standards (height-for-age z-score < -2 SD). Independent variables included infant sex (male or female) and birth weight categorized as low birth weight (LBW < 2,500 g) or normal (2,500 – 4,000 g). Chi-square tests were used to assess associations, with statistical significance set at $p < 0,05$. The prevalence of stunting in the study population was 34,6%. Birth weight demonstrated a statistically significant association with stunting (p = 0,048). Among children with low birth weight, 66,7% were stunted compared to 22,3% among those with normal birth weight. In contrast, infant sex was not significantly associated with stunting (p = 0,094), although a higher proportion of male children (43,6%) were stunted compared to females (27,8%). Low birth weight is significantly associated with an increased risk of stunting in early childhood. Infant sex was not a statistically significant factor in this study. These findings highlight the critical need for antenatal interventions targeting maternal nutrition to prevent low birth weight and reduce the risk of stunting.

Keywords: Stunting, Low Birth Weight, Infant Sex

Introduction

Stunting, a form of chronic undernutrition that results in impaired linear growth, is a significant public health concern with far reaching consequences for individuals and populations. According to the World Health Organization (WHO), stunting is defined as a height for age z-score (HAZ) less than minus two standard deviations from the WHO Child Growth Standards median(1). This condition reflects a cumulative process of undernutrition and exposure to recurrent infections, typically beginning in utero and continuing through the first two years of life. Stunting is not merely a biological anomaly but a marker of structural inequities that constrain early childhood development. It has been consistently associated with delayed cognitive development, poor educational achievement, reduced adult productivity, and increased risk of noncommunicable diseases(2, 3).

Globally, an estimated 148 million children under the age of five were stunted in 2023, with the majority residing in low and middle income countries (LMICs)(4). The burden is especially high in

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Africa and South Asia, where poverty, food insecurity, inadequate sanitation, and limited access to maternal and child health services continue to influence child growth trajectories(5). Indonesia, as the fourth most populous country in the world, bears a disproportionate share of this global burden. Despite national efforts to reduce stunting, the 2022 Indonesian Nutrition Status Survey (SSGI) reported a prevalence of 21.6% among children under five years, highlighting a persistent public health challenge(6). This figure remains above the government's 2024 target of less than 14%, as set out in the National Strategy for the Acceleration of Stunting Prevention (Stranas Stunting)(7).

The first 1,000 days of life from conception to the child's second birthday represent a critical window for growth and development. Interventions targeting this period are known to have the most significant impact on preventing stunting and its long term consequences(8). During this time, fetal growth, birth weight, early nutrition, and immune development are highly sensitive to maternal health, intrauterine environment, and postnatal caregiving practices. Among the biological factors influencing growth outcomes, birth weight is one of the most important and modifiable predictors of stunting.

Low birth weight (LBW), defined by the WHO as weight at birth less than 2,500 grams, is a widely used indicator of fetal growth restriction or prematurity(9). Globally, approximately 15% of all births are classified as LBW, with a higher proportion in South Asia and Southeast Asia(10). In Indonesia, the LBW prevalence stands at 6,2% according to the 2022 National Health Profile(11). LBW is a critical risk factor for neonatal morbidity and mortality and has long term consequences for physical and neurodevelopmental outcomes. The Developmental Origins of Health and Disease (DOHaD) theory provides a framework for understanding how adverse intrauterine environments often manifesting as LBW can permanently alter growth trajectories and increase susceptibility to stunting, metabolic disorders, and chronic diseases in later life(12).

Several studies have consistently shown an association between LBW and stunting. Biologically, infants born with restricted growth have reduced organ mass, fewer muscle fibers, and impaired renal and endocrine function, which limits their capacity for postnatal catch-up growth(13). Environmentally, LBW infants often require more intensive caregiving, face more frequent infections, and may experience poor feeding due to weak suckling reflexes or early weaning, particularly in low-resource settings(14).

In addition to birth weight, infant sex has emerged as a potential predictor of stunting. A growing body of literature has explored whether male or female children are more vulnerable to growth faltering during infancy and early childhood. Several multicenter studies and meta analyses suggest that male children are at higher risk of stunting, particularly during the first two years of life(15, 16). Biologically, male infants have higher basal metabolic rates, faster growth velocity, and increased nutritional demands, which may make them more susceptible to the adverse effects of undernutrition and infections. Moreover, males exhibit less mature immune systems at birth and may mount more intense inflammatory responses, contributing to a higher burden of infection-related growth failure(17).

However, the evidence on the role of sex in stunting is not consistent across regions or cultures. Some studies in South Asia have reported higher rates of stunting among girls, attributed to gender bias in caregiving, feeding practices, and health service utilization. In such contexts, female children may face discrimination in intra household food allocation and access to healthcare. In contrast, in most African and Southeast Asian settings, male disadvantage is more commonly observed. This suggests that the association between sex and stunting is context specific, influenced by an interplay of biological vulnerability and sociocultural norms. Moreover, it remains unclear whether sex and birth weight interact synergistically or independently influence the risk of stunting.

From a theoretical standpoint, the ecological model of child development provides a useful lens to understand how child growth outcomes, including stunting, are shaped by interactions between

individual, familial, community, and societal factors. At the individual level, biological factors such as sex and birth weight set the foundation for growth potential. At the familial level, maternal health, caregiving practices, and household food security influence whether that potential is realized. The broader context, including access to health services, cultural norms, and social safety nets, further modulates these influences. Therefore, investigating the roles of infant sex and birth weight must be situated within a broader ecological understanding of child development and nutrition(18).

Despite increasing global attention to early life determinants of stunting, few studies in Indonesia have comprehensively examined the combined influence of sex and birth weight on child growth outcomes, particularly in the post-neonatal period. National surveys such as the Indonesian Demographic and Health Survey (IDHS) and the Basic Health Research Survey (Riskesdas) provide valuable data on stunting prevalence and demographic patterns but do not always allow for detailed analysis of interaction effects between biological variables(19, 20). Moreover, while birth weight is routinely recorded in health facility settings, it is often underutilized in risk stratification and early intervention programs aimed at preventing growth faltering.

This study seeks to contribute to this area of inquiry by examining the association between infant sex and birth weight with the incidence of stunting among children aged 6–59 months in a health facility-based setting in Indonesia. By analyzing secondary data from routine health records, the study aims to identify whether sex and birth weight are significantly associated with stunting, and whether any interaction between these variables exists. The findings have the potential to strengthen early identification of high risk children and support efforts to design biologically informed, equity sensitive interventions to prevent stunting.

In addition, the study aligns with Indonesia's national priorities for stunting reduction and the global nutrition agenda under the Sustainable Development Goals (SDG's), which calls for ending all forms of malnutrition by 2030(21). Evidence-based policies that are grounded in local data and informed by biological risk factors are essential for making efficient use of limited resources in maternal and child health programming.

Method

This study employed a quantitative analytical approach with a cross sectional design to investigate the association between infant sex and birth weight with the incidence of stunting in children aged 6 to 59 months. The research was carried out in "x" village at North Sumatera. The population included all children aged 6–59 months residing in the area. A total of 127 children were included using purposive sampling based on specific inclusion criteria such as, availability of complete data and no chronic or congenital illness. Data were collected through by secondary data from report from January until July 2023, which provided reliable records of age, birth weight, sex, weight and lenght.

Stunting was defined based on the WHO Child Growth Standards as a height-for-age z-score (HAZ) below -2 SD. Infant sex was categorized as male or female, while birth weight was classified as low (< 2,500 g) or normal (2,500 – 4,000 g). All data were verified, anonymized, and analyzed using SPSS with Chi-square tests applied; significance was set at $p < 0,05$.

Results

A total of 127 children met the inclusion criteria and were analyzed in this study. These criteria included children with complete growth monitoring records and no history of congenital or chronic illness that could confound the anthropometric assessment. Based on WHO Child Growth Standards, stunting was defined as a height-for-age z-score (HAZ) below -2 SD.

Table 1. Distribution of Respondents by Infant Sex and Birth Weight (n = 127)

Variable	n	%
Sex		
Male	55	43,3
Female	72	56,7
Birth weight		
LBW	15	11,8
Normal	112	88,2

The distribution of respondents by sex indicates a higher proportion of females (56,7%) compared to males (43,3%). Although not the primary variable of interest, this sex distribution may reflect underlying demographic characteristics of the study setting or differential access to health services that could warrant further investigation.

Analysis of birth weight revealed that the vast majority of children (88,2%) were born with a normal birth weight (≥ 2,500 – 4,000 g), while a minority (11,8%) were classified as having LBW. This distribution suggests a relatively favorable perinatal profile in the sample population. Al though the prevalence of LBW in this study was relatively low, its potential impact on subsequent growth outcomes particularly linear growth faltering warrants critical attention. This is especially important considering the well established evidence linking intrauterine growth restriction (IUGR) with stunting during early childhood.

Table 2. Distribution of Stunting Status Among Children Aged 6–59 Months (n = 127)

Variable	n	%
Stunting	44	34,6
Normal	83	65,4

Table 2 shows the nutritional status of the 127 children aged 6–59 months who were included in the study. The data reveal that 44 children (34,6%) were categorized as stunted, while 83 children (65,4%) had normal height for age based on WHO growth standards. This indicates that more than one-third of the children in this population experienced chronic malnutrition as reflected by their stunted growth.

Table 3. Association Between Infant Sex and Birth Weight With Stunting

Variable	Stunting		p value
	Yes	No	
Sex			
Male	24	31	0,094
Female	20	52	
Birth weight			
LBW	10	5	0,048*
Normal	25	87	

Table 3 presents the results of the bivariate analysis exploring associations between infant sex and birth weight with the incidence of stunting in children aged 6–59 months. The analysis utilized the Chi-square test, with statistical significance set at $p < 0,05$.

Among the 127 children analyzed, 24 out of 55 males (43,6%) were found to be stunted, while 20 out of 72 females (27,8%) experienced stunting. Although a higher proportion of stunting was observed among males, the association between sex and stunting did not reach statistical significance ($p = 0,094$).

In contrast, a statistically significant association was found between birth weight and stunting incidence ($p = 0,048$). Specifically, 66,7% (10 out of 15) of children born with LBW were stunted, compared to only 22,3% (25 out of 112) among those with normal birth weight. This supports the theory that IUGR and LBW are strong predictors of chronic undernutrition, with effects that may persist throughout early childhood.

Discussion

Stunting, defined as a height-for-age z-score (HAZ) below -2 standard deviations (SD) according to WHO standards, reflects chronic malnutrition and long term deprivation of essential nutrients during critical periods of growth and development, particularly in the first 1,000 days of life (from conception to age 2 of childhood)(1).

The stunting prevalence of 34.6% in this population is categorized as high according to WHO criteria, which considers a prevalence above 30% as a critical public health concern(10). This suggests that chronic undernutrition remains a pressing issue in this area, consistent with the 2022 Indonesian national average of 21,6%, and notably higher than the global average of 22,3%(4, 6). This proportion may reflect persistent challenges in maternal and child nutrition, particularly in rural or underserved areas where access to optimal health services, clean water, sanitation, and early life nutrition may be inadequate.

The relatively high percentage of stunted children, despite some having normal birth weight, suggests that multidimensional poverty beyond birth conditions, such as inadequate complementary feeding, frequent infections, and poor parental knowledge about child nutrition may significantly contribute to growth (5, 22). Thus, the findings emphasize the need for integrated interventions targeting the first 1,000 days of life, from pregnancy through early childhood.

Although sex was not significantly associated with stunting in this study, a higher proportion of male children (43,6%) were stunted compared to female children (27,8%). This aligns with a number of global and national studies that report boys are more susceptible to growth faltering than girls during infancy and early childhood(23).

This finding aligns with a body of literature suggesting male children are biologically more vulnerable to early growth faltering due to immunological and metabolic differences during infancy. However, the lack of statistical significance may be due to sample size limitations or unmeasured confounders such as caregiving practices, exposure to infections, or feeding behaviors that were not controlled in this analysis. Therefore, while sex may be a contributing factor, it cannot be concluded as a determinant in this population without further multivariate analysis.

Biologically, male infants may have higher nutritional requirements, are more prone to infections, and have slower rates of physiological adaptation under stress, making them more vulnerable to growth retardation in adverse environments(17). A study in 36 low- and middle-income countries found that male children were consistently more stunted than female children, even after controlling for confounding factors such as socioeconomic status, birth weight, and maternal education(24).

However, cultural and caregiving practices can sometimes mitigate or exacerbate these biological predispositions. For example, in some societies, boys receive preferential feeding and care, while in others, girls are more protected from environmental exposures. In the current study setting, the absence of a significant association might reflect relatively equitable treatment of boys and girls or simply be due to the sample size. The marginal p-value (0,094) suggests that with a larger sample, the difference might reach statistical significance.

Low birth weight was found to be significantly associated with the incidence of stunting (p = 0,048). Among children with LBW, 66,7% were stunted compared to only 22,3% of those born with normal weight. This result is consistent with the theory of the "fetal origins of adult disease" or the "developmental origins of health and disease (DOHaD)", which posits that undernutrition in utero leads to permanent structural and functional changes that compromise postnatal growth, metabolism, and immunity(12).

A meta-analysis by Christian et al. (2013) demonstrated that LBW infants have a 2.5 times higher risk of stunting during childhood(25). More recently, a study in Ethiopia confirmed that birth weight is a strong predictor of stunting up to age five. This association can be explained by several mechanisms: LBW may result from intrauterine growth restriction (IUGR), which is closely linked to maternal malnutrition, anemia, and infections during pregnancy. These children start life with diminished growth potential and often continue to live in environments that do not support catch-up growth(26).

Importantly, LBW is not only a biological issue but also a proxy for socioeconomic and healthcare disparities. In low-resource settings, the likelihood of LBW is compounded by poor maternal nutrition, inadequate antenatal care, and limited access to skilled birth attendance all factors prevalent in rural Indonesia. This creates a vicious cycle where poor maternal health leads to low birth weight infants who are then at greater risk of stunting, poor cognitive development, and reduced economic productivity in adulthood.

The findings of this study are in line with prior research conducted in both national and international contexts. A study from 2021 Indonesian National Nutritional Status Survey, found that low birth weight was significantly associated with stunting(27). Similarly, research in Nepal and Bangladesh found that LBW infants had a significantly higher risk of being stunted at 2 years of age, even after controlling for household wealth and maternal education(28). Conversely, the lack of a significant relationship between infant sex and stunting in this study differs from other studies, such as one conducted in low to middle country, which found male children to be more likely to be stunted. This discrepancy may reflect differences in social norms, child-rearing practices, or sample sizes across studies(15).

The significant link between LBW and stunting observed here suggests that interventions aimed at improving maternal health and prenatal care could play a pivotal role in reducing childhood stunting. Evidence based interventions such as maternal supplementation with balanced energy protein, iron folic acid, intermittent preventive treatment for malaria, and skilled antenatal care can significantly reduce the incidence of LBW(8).

Additionally, the high stunting prevalence regardless of sex highlights the need for multi-sectoral strategiesintegrating health, nutrition, water and sanitation (WASH), education, and poverty alleviation. The government of Indonesia, through the National Strategy to Accelerate Stunting Reduction (Stranas Stunting), has begun implementing such strategies, but as this study indicates, local-level challenges persist(7).

A major strength of this study is its use of community level data and standardized anthropometric measurements aligned with WHO growth standards. However, several limitations should be noted. The cross sectional design limits the ability to establish causal relationships. The use of secondary data may introduce measurement bias, and unmeasured confounding variables (e.g.,

feeding practices, maternal height, and socioeconomic status) could influence both birth weight and stunting risk. Furthermore, the sample size, though adequate for basic analysis, may have limited the statistical power to detect subtler associations, such as sex differences.

Conclusion

This study highlights that low birth weight is a significant predictor of stunting among children under five, reinforcing the need to strengthen maternal health programs, particularly in rural settings. While infant sex was not significantly associated with stunting, observed trends merit further exploration in larger and more diverse samples. Future research should incorporate longitudinal designs to better understand causal pathways and include a broader set of covariates, including maternal nutrition, caregiving practices, and household socioeconomic factors.

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