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Factors Associated with Stunting in Toddlers in Indonesia: Analysis of the 2024 Indonesian Nutrition Status Survey (SSGI) for Evidence-Based Nutrition Policy

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Abstract: Stunting remains a major public health challenge in Indonesia and is associated with multiple biological, maternal, social, and environmental factors. This study aimed to identify factors associated with stunting among toddlers in Indonesia and characterize geographic variation in stunting prevalence across provinces using the 2024 Indonesian Nutrition Status Survey (SSGI). This cross-sectional observational study used data from 298,970 toddlers across 38 provinces and 510 districts/cities. Weighted multivariable logistic regression with province as a fixed effect was used to estimate adjusted odds ratios (AORs), complemented by Global Moran's I, Local Indicators of Spatial Association (LISA), and quantile mapping to assess geographic distribution and spatial autocorrelation. The prevalence of stunting was 22.7%. Males (OR 1.11), children living in rural areas (OR 1.32), those aged 24–35 months (OR 1.29), those with low birth weight (OR 2.08), and those born prematurely (OR 1.34) had higher odds of stunting. Lower parental education, iron supplementation of <90 tablets, incomplete antenatal care, maternal anaemia, chronic energy deficiency, inadequate sanitation (OR 1.44), inadequate drinking water (OR 1.45), and high residential density (OR 1.38) were also significantly associated with stunting ($p < 0.05$). Significant differences in adjusted odds were observed across provinces ($\chi^2 = 618.977$; $p < 0.001$), with the highest AORs in Highlands Papua (5.82; 95% CI: 3.55–9.56) and East Nusa Tenggara (4.69; 95% CI: 3.70–5.95), compared with Bali as the reference province. Spatial analysis demonstrated significant positive spatial autocorrelation (Moran's I = 0.3634; Z = 2.7271; $p = 0.01$), with high-prevalence clustering in the eastern region. Stunting was associated with multiple individual, household, and environmental factors and showed significant geographic clustering across Indonesian provinces. Evidence-based, geographically targeted strategies should prioritise interventions from pregnancy through the first two years of life, nutritional literacy, immunisation coverage, sanitation, drinking water, and healthy housing, particularly in high–high spatial clusters.
Keywords: Associated factors; logistic regression; sanitation; spatial autocorrelation; stunting; toddlers.

INTRODUCTION

Malnutrition is a serious global public health problem due to its long-term impacts on cognitive development, socioeconomic status, and human productivity[1,2]. This condition includes nutrient, vitamin, and mineral deficiencies, as well as overweight and

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diet-related non-communicable diseases[1]. In children, the main forms of malnutrition include stunting, wasting, and underweight[1]. By 2022, an estimated 149 million stunted and 45 million wasted children will be found globally, while nearly half of under-five deaths are attributed to malnutrition, particularly in low- and middle-income countries[1].

Stunting remains a major threat to the quality of human resources in both developed and developing countries[3]. Direct factors associated with stunting include the quality of the child at birth, which is influenced by maternal health and gestational age, as well as the child's sex[4]. Poor maternal nutritional status before and during pregnancy can lead to low birth weight, a major risk factor for stunting[5]. A child is categorised as stunted if their height-for-age is <-2 SD from the median WHO Child Growth Standards for the same age and sex[6].

The World Health Assembly targets a 40% reduction in stunting prevalence by 2025[7]. Globally, the prevalence decreased from 22.7% in 2020 to 22.3% in 20221, but this rate is insufficient to achieve SDG 2.2, which aims to end all forms of malnutrition by 2025[8]. Risk factors for stunting are multifactorial, including household conditions, breastfeeding and feeding practices, infections, and environmental factors such as water, sanitation, education, and socioeconomic status[9]. Previous research has also confirmed the role of the child's age and sex, low birth weight, maternal body mass index, parental education, sanitation conditions, and history of diarrhoea in stunting incidence[10-12].

Empirical evidence in Indonesia shows a similar pattern. Children aged 12–23 months have a 2.83 times higher risk of stunting than children under 12 months, and children in urban areas are at 1.12 times higher risk than in rural areas[13]. Environmental factors such as unsafe drinking water sources and poor sanitation also increase the risk[14], while inappropriate parenting and low socioeconomic status contribute[15].

In Indonesia, the prevalence of stunting decreased from 21.6% in 2022 to 19.8% in 2024[16], but this figure remains far from the national target of 14% in the 2024 National Medium-Term Development Plan. Variations between provinces also remain large, reflecting significant social, economic, and environmental inequalities.

A review of the research context indicates that the factors most consistently associated with stunting across studies are maternal education, maternal nutritional status, low birth weight, access to safe drinking water, and household sanitation conditions. However, most previous studies in Indonesia—including those using the 2022 SSGI data—have focused on partial or local-scale analyses and have not comprehensively integrated multifactorial and spatial approaches across provinces.

This study updates these analyses using 2024 SSGI national data and a multivariable approach that combines individual, household, and environmental factors to explain variation in stunting risk across provinces. This approach is expected to provide a more comprehensive understanding of spatial inequalities and the key determinants contributing to the high prevalence of stunting in Indonesia.

The findings of this study are expected to inform the formulation of evidence-based, sustainable nutrition policies, focusing on contextual, targeted, and effective interventions tailored to regional characteristics. Therefore, this study aims to identify the key determinants of stunting in children under five in Indonesia and provide policy recommendations based on national data to accelerate stunting reduction and improve child health sustainably.

MATERIALS AND METHODS

Design and Data Sources

This cross-sectional observational study uses secondary data from the 2024 Indonesian Nutrition Status Study (SSGI), conducted by the Indonesian Ministry of Health in collaboration with the Central Statistics Agency (BPS). The survey was conducted in 38 provinces and 510 districts/cities from October 2024 to February 2025. It was designed to estimate the nutritional status of toddlers and its determinants at the provincial level.

Population and Criteria

The population included all households with children aged 0–59 months who participated in the 2024 SSGI. Inclusion criteria were toddlers with complete height and age data and households with valid socioeconomic and environmental data. Exclusions included incomplete anthropometric data, extreme height/age z-scores ($z < -6$ or $z > +6$), and observations with missing key variables. We analyzed 298,970 toddlers, representing approximately 15 million toddlers nationwide, with a margin of error of ±2%. The sample size was derived from the BPS survey design, with a post-design power >0.9 to detect an OR≥1.2 ($\alpha = 0.05$).

Procedure and Data Collection

The sample was selected using two-stage stratified cluster sampling, using the Probability Proportional to Size (PPS) method in the first stage and systematic random household selection in the second stage. Data were collected using Computer-Assisted Personal Interviews (CAPI) using two questionnaires: household (socioeconomic, sanitation, drinking water, housing density) and individual (child characteristics, pregnancy history, breastfeeding, immunization, morbidity). Trained personnel conducted anthropometric measurements using calibrated instruments according to the WHO Child Growth Standards (2006), with daily quality control and consistency checks.

Variables and Operational Definitions

Nutritional status of children under five was measured using the Height for Age (H/U) indicator based on WHO standards (2006); children were categorized as stunted if the z-score was < -2 SD and not stunted if it was ≥ -2 SD. Environmental variables refer to the WHO/UNICEF Joint Monitoring Programme (JMP) definition, with adequate sanitation including the use of a gooseneck toilet or septic tank, and improved drinking water sources including tap water, drilled wells, or protected refilled water. Housing density is categorized as dense if the floor area is <8 m^2 per person, and residential classification follows the BPS division into rural and urban areas.

Independent variables are grouped into four: (1) child factors, including gender, age group, exclusive breastfeeding status, still breastfeeding at 12–23 months, completeness of immunizations, and domicile; (2) birth factors, including low birth weight (<2500 g) and premature birth (<37 weeks); (3) parental and maternal factors, including paternal and maternal education, maternal occupation, maternal age at risk (<20 or ≥35 years), iron supplementation tablet (TTD) consumption <90 tablets, completeness of antenatal care (ANC) visits, history of nutritional counseling, anemia (Hb <11 g/dL), and chronic energy deficiency (LiLA <23.5 cm); and (4) household environmental factors, including sanitation conditions, drinking water sources, and housing density. All variables were coded dichotomously (1 = at risk, 0 = reference). Province effects were included as dummy variables to generate Adjusted Odds Ratios (AORs) between provinces.

Data Analysis

Data were cleaned and merged between household and individual modules using unique identification numbers. Sampling weights provided by BPS were applied to account for the survey sampling design and to obtain population-representative estimates. Descriptive analyses summarised the study population's characteristics. Bivariate associations between independent variables and stunting status were assessed using the Chi-square test.

Variable selection for the multivariable analysis was guided a priori by the UNICEF conceptual framework for determinants of child undernutrition (2020), the SSGI 2024 guidelines, and epidemiological considerations regarding variables that could act as important confounders. We used bivariate statistical significance as an exploratory criterion. Still, it was not the sole basis for variable selection—variables considered theoretically relevant as potential confounders were retained in the multivariable model regardless of their bivariate p-values.

We used weighted multivariable binary logistic regression to estimate adjusted odds ratios (AORs) with 95% confidence intervals (CIs) for the association between the independent variables and stunting status. Province was included in the model as a categorical fixed-effect variable, with Bali as the reference category, to assess adjusted differences in the odds of stunting across provinces. The model adjusted for relevant child, maternal, household, environmental, socioeconomic, and feeding-related factors identified a priori. Statistical significance was assessed at $p<0.05$.

All statistical analyses were performed using IBM SPSS Statistics version 26.0 with the available survey weights. To assess geographic variation in stunting prevalence, spatial autocorrelation analyses were conducted using a queen-contiguity spatial weights matrix. Global Moran's I was calculated to assess overall spatial autocorrelation, while Local Moran's I (LISA) was used to identify statistically significant local spatial clusters and spatial outliers. Quantile mapping of provincial stunting prevalence was also used to visualize the geographic distribution of provinces by low, medium, and high prevalence categories.

Ethical Considerations

This study used anonymized secondary data from the 2024 SSGI, which had received ethical approval from the National Health Research Ethics Committee. The analysis was conducted without individual identification, maintaining the confidentiality and anonymity of all respondents, and presenting results only at the provincial and national levels.

RESULTS AND DISCUSSION

We conducted bivariate analyses to assess factors associated with stunting among Indonesian children. Most variables showed significant associations with stunting ($p < 0.05$). As shown in Table 1, stunting was more common among boys than girls and among children living in rural areas. The highest proportion of stunting was observed among children aged 24–35 months. Low birth weight and preterm birth were also significantly associated with stunting ($p < 0.001$). The distribution and strength of these associations are presented in Table 1.

Table 1. Characteristics and Crude Associations of Stunting Among Children Aged 0–59 Months in Indonesia, SSGI 2024

Category / Variable	Not Stunted, n (%)	Stunted, n (%)	Total, n (%)	p-value
Child Characteristics				
Sex				
Male	117,037 (39.1)	36,629 (12.3)	153,666 (51.4)	<0.001
Female (ref)	114,005 (38.1)	31,299 (10.5)	145,304 (48.6)	
Residence				
Rural	105,035 (35.1)	36,900 (12.3)	141,935 (47.5)	<0.001
Urban (ref)	126,007 (42.1)	31,028 (10.4)	157,035 (52.5)	
Age (months)				
0–5	15,154 (5.1)	2,110 (0.7)	17,264 (5.8)	<0.001
6–11	23,891 (8.0)	3,731 (1.2)	27,622 (9.2)	<0.001
12–23	45,454 (15.2)	14,911 (5.0)	60,365 (20.2)	<0.001
24–35	47,228 (15.8)	16,887 (5.4)	65,693 (22.0)	<0.001
36–47	49,431 (16.5)	16,262 (4.7)	65,693 (22.0)	<0.001
48–59 (ref)	49,884 (16.7)	14,027 (4.7)	63,911 (21.4)	
Breastfeeding and Immunization				
Not exclusively breastfed	2,980 (30.6)	495 (5.1)	3,475 (35.7)	<0.001
Exclusively breastfed (ref)	5,538 (56.9)	725 (7.4)	6,263 (64.3)	
Incomplete immunization	24,130 (40.0)	9,093 (15.1)	33,223 (55.0)	<0.001
Complete (ref)	21,324 (35.3)	5,818 (9.6)	27,142 (45.0)	
Birth Status				
Low birth weight (<2,500 g)	11,587 (4.2)	6,408 (2.3)	17,995 (6.5)	<0.001
Normal birth weight (ref)	205,909 (73.9)	54,722 (19.6)	260,631 (93.5)	
Preterm (<37 weeks)	31,616 (11.2)	11,582 (4.1)	43,198 (15.3)	<0.001
Term birth (ref)	187,437 (66.5)	51,277 (18.2)	238,714 (84.7)	
Parental Factors				
Father's education				
Low	93,844 (32.7)	34,574 (12.0)	128,418 (44.7)	<0.001
Moderate	97,233 (33.9)	24,535 (8.5)	121,768 (42.4)	<0.001
High (ref)	30,899 (10.8)	5,958 (2.1)	36,857 (12.8)	
Mother's education				
Low	93,176 (31.6)	34,766 (11.8)	127,931 (43.4)	<0.001
Moderate	93,676 (31.8)	24,437 (8.3)	118,113 (40.1)	<0.001
High (ref)	40,808 (13.9)	7,712 (2.6)	48,520 (16.5)	
Mother not working	142,735 (48.5)	43,813 (14.9)	186,548 (63.3)	<0.001
Working (ref)	84,925 (28.8)	23,091 (7.8)	108,016 (36.7)	
Maternal and Pregnancy Factors				
High-risk maternal age (<20 / ≥35 years)	58,533 (19.7)	18,812 (6.3)	77,345 (26.0)	<0.001
Normal maternal age (ref)	171,231 (57.6)	48,668 (16.4)	219,899 (74.0)	
<90 iron tablets	84,336 (34.4)	27,454 (11.2)	111,790 (45.5)	<0.001
≥90 tablets (ref)	106,438 (43.4)	27,221 (11.1)	133,659 (54.5)	

Incomplete ANC	8,365 (2.8)	4,227 (1.4)	12,592 (4.3)	<0.001
Complete ANC (ref)	218,576 (74.4)	62,488 (21.3)	281,064 (95.7)	
Environmental and Household Factors				
High housing density (<8 m²/person)	26,477 (9.7)	11,151 (4.1)	37,628 (13.8)	<0.001
Adequate housing density (ref)	184,742 (67.7)	50,516 (18.5)	235,258 (86.2)	
Poor sanitation	18,332 (7.0)	8,244 (3.1)	26,576 (10.1)	<0.001
Adequate sanitation (ref)	185,990 (70.5)	51,194 (19.4)	237,184 (89.9)	
Unsafe drinking water	8,365 (3.1)	3,968 (1.5)	12,333 (4.5)	<0.001
Safe drinking water (ref)	202,854 (74.3)	57,699 (21.1)	260,553 (95.5)	

Note: Percentages are based on variable-specific denominators because some variables were available only for specific age groups or had missing observations. Percentages therefore do not necessarily sum to 100% across all variables. The total sample for the overall stunting analysis was 298,970 children, comprising 231,042 (77.3%) non-stunted and 67,928 (22.7%) stunted children. We used chi-square tests for bivariate comparisons. Reference categories are indicated by “ref”.

Parental characteristics were also significantly associated with stunting. Children of fathers and mothers with lower educational attainment had a higher proportion of stunting than those whose parents had higher education. Maternal employment status was also significantly associated with stunting. Among maternal and pregnancy-related factors, high-risk maternal age, consumption of fewer than 90 iron tablets, and incomplete antenatal care were significantly associated with stunting. Similarly, environmental and household characteristics, including high housing density, inadequate sanitation, and unsafe drinking water, were significantly associated with stunting.

These findings represent bivariate associations and should not be interpreted as independent effects because the estimates in Table 1 did not fully account for potential confounding or the complex survey design. Variables for multivariable analysis were therefore selected based on a priori theoretical considerations, the UNICEF conceptual framework, SSGI 2024 guidelines, and their potential role as confounders, rather than solely on bivariate statistical significance.

To assess whether differences in stunting persisted across provinces after adjustment for individual-, maternal-, household-, and environmental-level factors, we used a multivariable binary logistic regression model with province entered as a categorical variable and Bali as the reference category. Table 2 presents the available adjusted provincial estimates as adjusted odds ratios (AORs) with 95% confidence intervals (CIs). These estimates describe the adjusted differences in the odds of stunting between provinces after accounting for the covariates included in the model.

Multivariable analysis demonstrated substantial variation in the odds of stunting across provinces ($\chi^2 = 618.977$; $p < 0.001$). Compared with Bali as the reference province, Highlands Papua (AOR 5.82; 95% CI: 3.55–9.56) and East Nusa Tenggara (AOR 4.69; 95% CI: 3.70–5.95) had the highest adjusted odds of stunting, indicating substantially higher odds in these provinces. In contrast, provinces in western Indonesia, including West Java and Lampung, showed lower but still significantly elevated odds compared with Bali.

Table 2. Adjusted Odds of Stunting by Province, SSGI 2024

Province	AOR (Exp[B])	95% CI	p-value
Aceh	2.709	2.116–3.467	<0.001
North Sumatra	2.613	2.057–3.321	<0.001
West Sumatra	2.140	1.668–2.745	<0.001
Riau	2.057	1.583–2.672	<0.001
Jambi	1.688	1.284–2.219	<0.001
South Sumatra	1.588	1.238–2.036	<0.001
Bengkulu	1.935	1.464–2.558	<0.001
Lampung	1.468	1.138–1.893	0.003
Bangka Belitung Islands	1.940	1.454–2.589	<0.001
Riau Islands	1.809	1.338–2.445	<0.001
Jakarta	2.044	1.498–2.791	<0.001
West Java	1.331	1.046–1.695	0.020
Central Java	1.604	1.275–2.019	<0.001
Yogyakarta	2.452	1.809–3.325	<0.001
East Java	1.479	1.176–1.861	0.001
Banten	1.989	1.507–2.625	<0.001
Bali (ref)	**1.000**	**Reference**	**—**
West Nusa Tenggara	2.954	2.277–3.834	<0.001
East Nusa Tenggara	4.083	3.218–5.179	<0.001
West Kalimantan	2.241	1.747–2.876	<0.001
Central Kalimantan	2.299	1.774–2.981	<0.001
South Kalimantan	1.897	1.466–2.455	<0.001
East Kalimantan	2.971	2.286–3.861	<0.001
North Kalimantan	2.180	1.540–3.085	<0.001
North Sulawesi	2.591	2.017–3.328	<0.001
Central Sulawesi	2.364	1.816–3.078	<0.001
South Sulawesi	1.765	1.385–2.250	<0.001
Southeast Sulawesi	2.983	2.298–3.873	<0.001
Gorontalo	1.686	1.229–2.314	0.001
West Sulawesi	3.147	2.331–4.248	<0.001
Maluku	3.212	2.403–4.293	<0.001
North Maluku	2.160	1.600–2.916	<0.001
West Papua	1.496	1.034–2.164	0.033
Southwest Papua	1.843	1.212–2.804	0.004
Papua	3.213	2.425–4.258	<0.001
South Papua	3.105	1.971–4.892	<0.001
Central Papua	3.407	2.128–5.455	<0.001
Highland Papua	6.090	3.657–10.140	<0.001

Note: AOR = adjusted odds ratio; CI = confidence interval. Bali was used as the reference province. We obtained the provincial estimates from the available multivariable logistic regression output after adjustment for the individual-, maternal-, household-, environmental-, and child-related variables described in the Methods. Only adjusted estimates available from the retained regression output are presented. Individual-level

AORs are not reported because the corresponding regression output is no longer available.

Overall, the findings indicate pronounced geographic variation in stunting risk across Indonesia, with higher adjusted odds generally observed in several eastern provinces and lower odds in western provinces. Table 2 presents the provinces with the highest and lowest AORs, together with selected representative provinces, to illustrate the geographic pattern. The complete analysis of all 38 provinces showed a broadly consistent pattern, with stunting odds tending to increase across several provinces in eastern Indonesia.

The geographic distribution of stunting prevalence across Indonesia's 38 provinces is presented using a quantile classification map (Figure 1A). The provinces were grouped into three prevalence categories based on the distribution of stunting prevalence, allowing visualisation of the spatial pattern of areas with relatively low, moderate, and high prevalence. The map showed a non-random geographic distribution, with provinces sharing similar levels of stunting prevalence tending to occur in geographically adjacent areas. Higher-prevalence provinces were concentrated in particular geographic regions, whereas lower-prevalence provinces were more frequently observed in other regions, suggesting a geographic pattern in the distribution of stunting prevalence.

Global spatial autocorrelation was assessed using Global Moran's I. The analysis showed positive and statistically significant spatial autocorrelation in stunting prevalence across Indonesian provinces, with a Moran's I value of 0.3634, a Z-value of 2.7271, and a p-value of 0.01. The positive Moran's I value indicates that provinces with similar stunting prevalence tended to be geographically closer than expected under spatial randomness. This finding confirms that the provincial distribution of stunting prevalence exhibited significant spatial dependence, with areas of relatively high or low prevalence tending to cluster geographically.

Local spatial autocorrelation analysis using Local Indicators of Spatial Association (LISA) further identified specific provinces contributing to the overall spatial pattern (Figure 1B). The LISA analysis revealed distinct spatial clusters, including high–high (HH) clusters, representing provinces with high stunting prevalence surrounded by provinces with similarly high prevalence, and low–low (LL) clusters, representing provinces with low prevalence surrounded by provinces with similarly low prevalence. High–low (HL) and low–high (LH) spatial outliers, where present, represented provinces whose stunting prevalence differed from that of their neighbouring provinces. These local patterns provide a more detailed representation of the geographic heterogeneity of stunting prevalence across Indonesia.

Overall, the spatial analyses demonstrated that stunting prevalence across Indonesia was characterised by significant spatial clustering and local geographic heterogeneity. The quantile map (Figure 1A) provided an initial visualisation of the geographic distribution, while the significant positive Global Moran's I statistic confirmed that the observed pattern was not spatially random. The LISA analysis (Figure 1B) then identified specific local clusters and spatial outliers, highlighting geographic areas where high or low stunting prevalence tended to occur alongside neighbouring provinces. Together, these findings indicate that the distribution of stunting prevalence has an important spatial dimension and provide a geographic basis for identifying areas that may warrant greater attention in stunting prevention and control.

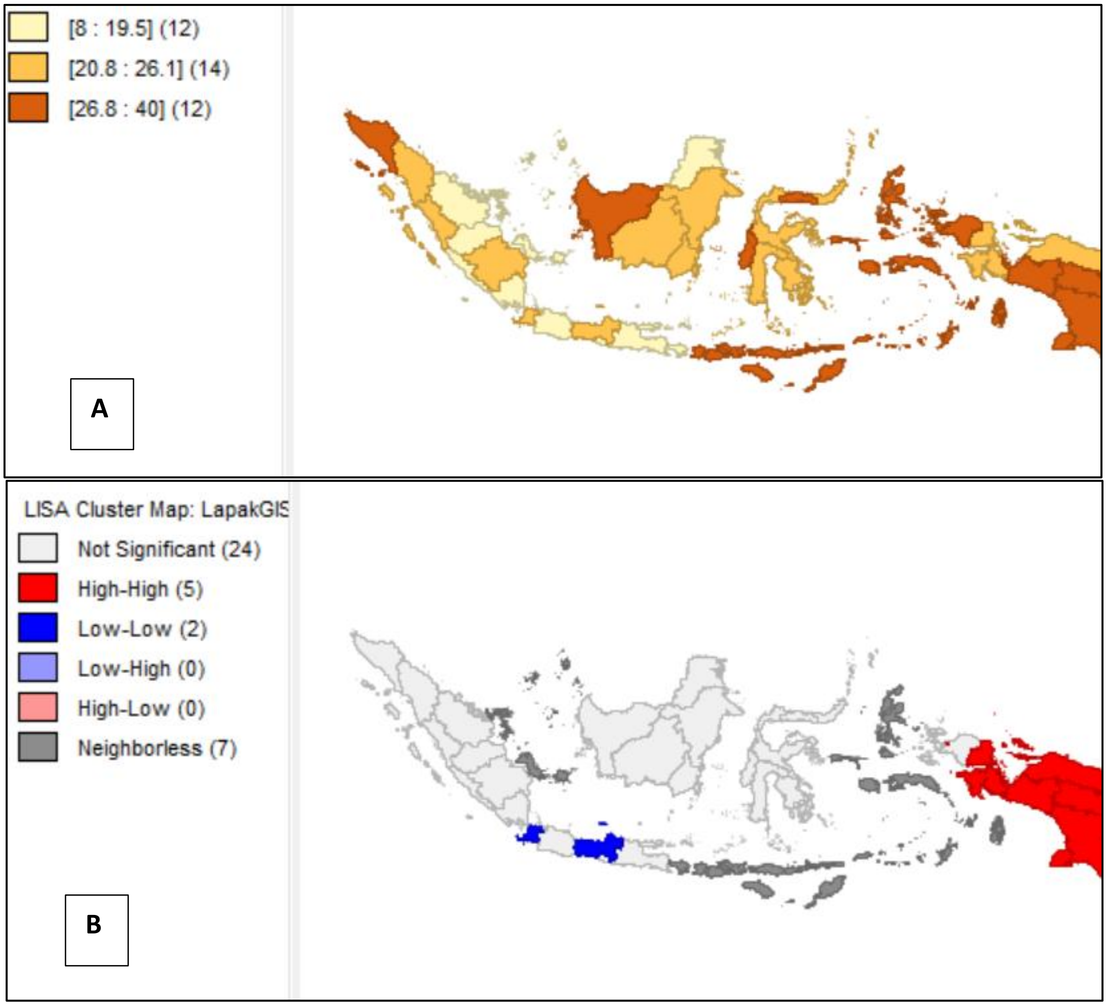

Figure 1. Geographic distribution and spatial autocorrelation of stunting prevalence across Indonesia's 38 provinces. (A) Quantile map showing the geographic distribution of stunting prevalence across Indonesian provinces. (B) Local Indicators of Spatial Association (LISA) cluster map showing significant local spatial clusters and spatial outliers of stunting prevalence.

The results of this study indicate that biological, maternal, social, and environmental factors were significantly associated with stunting, with a higher prevalence observed among boys, children with low birth weight, children of mothers with lower educational attainment, and children living in households with inadequate sanitation and drinking water. Although the 2024 SSGI data are nationally representative, these results have limitations because the cross-sectional design cannot confirm causal relationships. Furthermore, possible reporting bias and limited maternal behavioural variables may influence the observed associations, but do not diminish the validity of the main findings, which are consistent with global evidence.

Biological Factors

Boys had a higher prevalence of stunting than girls, as reported by Amadu et al. (2021)[17], which explains that boys' energy needs and biological vulnerability to infection are greater, especially in environments with high pollution exposure and morbidity[18]. Stunting was also more prevalent among children aged 12–35 months, a phase when nutritional intake from complementary foods is often insufficient to meet growth needs[19]. In addition, children with low birth weight (LBW) and those born prematurely had a higher prevalence of stunting, supporting the findings of Ahinkorah (2021)[20]. This finding highlights the importance of nutritional interventions for pregnant women, including adequate iron intake and a balanced nutritious diet[21], which may help reduce the occurrence of LBW and improve early-life nutritional outcomes.

Maternal and Social Factors

Maternal age during pregnancy was also significantly associated with a child's nutritional status. Pregnancy at age <20 years or ≥35 years has been associated with a higher prevalence of pregnancy complications and fetal growth restriction[22,23]. Parental education, especially maternal education, plays a crucial role because it relates to knowledge of nutrition practices and child health13,19. Parents with lower educational attainment may have more limited access to health information and nutrition services, which may contribute to differences in child nutritional outcomes. Therefore, strengthening nutritional literacy through prenatal classes, integrated health posts (Posyandu), and family empowerment programs may be an important component of improving household nutritional practices.

Environmental Factors

Residential environmental conditions have been associated with children's nutritional status. Children living in households with inadequate sanitation and unsafe drinking water sources had a higher prevalence of stunting[14,24]. Exposure to unhygienic environments has been associated with a greater occurrence of enteric infections, which may adversely affect nutrient absorption. Furthermore, high residential density has been associated with poorer environmental conditions, including greater potential for disease transmission and reduced indoor air quality. Interventions that increase access to clean water, develop safe sanitation, and improve housing are important components of a multisectoral stunting reduction program, as recommended by WHO and UNICEF.

Spatial Variation Between Provinces

Spatial analysis showed significant positive spatial autocorrelation between provinces (Moran's I = 0.3634; Z = 2.7271; p = 0.01), indicating a geographic clustering pattern with high-prevalence clusters in eastern regions such as Highlands Papua, Central Papua, and East Nusa Tenggara, and low prevalence in Bali, Jakarta, and Yogyakarta. These findings are consistent with those of Tahangnacca and Muntahaya (2023) and Sipahutar et al. (2022), which reported that spatial clustering patterns were associated with social and cultural disparities and access to health services[25,26]. These results also support the findings of Kurniawati et al. (2025), who reported that poverty, maternal knowledge about stunting, and basic immunisation coverage were important factors associated with spatial variation between provinces[27]. Therefore, an area-based approach may be warranted to prioritise interventions in high–high cluster provinces, particularly in eastern Indonesia.

Policy Implications

This study emphasises the importance of a comprehensive approach to accelerating stunting reduction. These efforts need to integrate specific nutrition interventions (iron supplementation, exclusive breastfeeding, pregnancy monitoring, and maternal nutrition education) with sensitive nutrition interventions (improved sanitation, clean water, and family economic empowerment). Local governments need to strengthen cross-sectoral coordination through area-based and evidence-based targeting strategies to reach areas with a high prevalence of stunting.

The main strength of this study is its use of national data from the 2024 SSGI, covering 38 provinces, and a multivariable approach that comprehensively depicts spatial variation and factors associated with stunting. This analysis provides an up-to-date picture of inter-regional disparities and can inform national data-driven policymaking. However, the study's cross-sectional design cannot confirm causal relationships, and the limited use of maternal behaviour and dietary intake variables, which were not fully measured in the survey, also limits the findings. Longitudinal research and the integration of micro-socioeconomic data are recommended to strengthen the understanding of causality in the future.

CONCLUSION

Stunting among children under five in Indonesia was significantly associated with biological, maternal, social, and environmental factors, with spatial patterns indicating higher stunting prevalence in several eastern regions, particularly Papua and East Nusa Tenggara. Key consistent factors associated with stunting included older child age, male sex, low birth weight, lower parental educational attainment, and inadequate sanitation and drinking water. Accelerating stunting reduction requires a focus on nutrition interventions from pregnancy through the first two years of life, increasing nutrition literacy, and improving sanitation through cross-sectoral collaboration in areas with a high prevalence of stunting. This study provides the latest national evidence to support evidence-based, sustainable nutrition policies to accelerate progress toward the 2024 National Medium-Term Development Plan (RPJMN) and SDG 2.2. Future research should use longitudinal designs to assess causal relationships and integrate spatial and behavioural data to understand cultural factors and the effectiveness of stunting reduction interventions.

CONFLICT OF INTEREST

In this study there is no conflict of interest

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