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Socioeconomic determinants of stunting severity among children under two in rural Polewali Mandar: an ordinal logistic regression analysis

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ABSTRACT

Background: *Stunting remains a critical public health emergency in Indonesia, with national prevalence of 21.6% in 2022 still exceeding the WHO 20% emergency threshold; West Sulawesi province recorded the third-highest provincial prevalence nationally (35.0%), with Polewali Mandar Regency identified as a principal contributing district. Severe stunting carries substantially greater risk of child mortality and cognitive impairment than moderate stunting, yet stunting severity remains underanalyzed in district-level policy, as most studies rely on binary stunted/not-stunted classification.* ***Objective:*** *This study examines socioeconomic determinants of stunting severity among children under two in rural Polewali Mandar.* ***Methods:*** *A cross-sectional study was conducted among 165 children under two years of age in rural households of Mapilli sub-district, Polewali Mandar Regency, enrolled through consecutive sampling from an estimated 580 eligible children (28.4% coverage). Stunting severity, based on height-for-age z-scores, was categorized into three ordinal levels (not stunted, moderate stunting, severe stunting). Six predictors household economic status, maternal education, latrine ownership, drinking water source, posyandu visit frequency, and health facility access were assessed via structured interviews. Ordinal logistic regression under the Proportional Odds Model (POM) was applied, with the parallel regression assumption confirmed via the Brant test (omnibus $X^2 = 14.07$, $df = 11$, $p = 0.23$).* ***Results:*** *Stunting prevalence reached 46.67% (32.12% moderate, 14.55% severe), more than twice the WHO emergency threshold. Four significant predictors were identified: household economic status (moderate vs low, OR = 2.194, 95% CI 1.063–4.605, p = 0.035; high vs low, OR = 5.072, 95% CI 1.628–17.679, p = 0.007), ineligible drinking water source (OR = 0.180, 95% CI 0.038–0.744, p = 0.021), irregular posyandu attendance (OR = 0.352, 95% CI 0.140–0.877, p = 0.024), and difficult health facility access (OR = 0.048, 95% CI 0.009–0.208, p < 0.001). The model explained a moderate share of variance (Nagelkerke $R^2 = 0.321$)* ***Conclusions:*** *Household economic status, drinking water source, posyandu attendance, and health facility access were significantly associated with stunting severity in this rural setting. Given the cross-sectional design, these findings reflect associations rather than causal relationships. Severity-graded analysis provides more operationally relevant evidence than binary approaches for targeting rural interventions, pending confirmation from longitudinal research.*

KEYWORDS: *growth disorder; Indonesia; logistic models; rural population; socioeconomic factors*

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INTRODUCTION

Stunting, defined as impaired linear growth resulting in a height-for-age z-score (HAZ) below negative two standard deviations from the median of the World Health Organization (WHO) Child Growth Standards, remains one of the most pervasive public health challenges in low- and middle-income countries (LMICs). Beyond its immediate manifestation as a physical growth deficit, stunting carries profound long-term consequences, including impaired cognitive development, diminished educational attainment, reduced adult economic productivity, and elevated risk of non-communicable diseases in later life [1]. Globally, an estimated 148.1 million children under five years of age were stunted as of 2022, with the highest burden concentrated in South Asia and sub-Saharan Africa. Although stunting prevalence has generally declined across LMICs over the past two decades, this decline has not occurred uniformly across socioeconomic groups [2,3]. This pattern indicates that stunting is not merely a nutritional problem but also reflects differential access to resources, healthy environments, and essential health services underscoring the need to identify the specific determinants that shape a child's risk of growth failure [4].

Indonesia has made measurable progress in reducing stunting prevalence, from 30.8% in 2018 [5] to 21.6% in 2022 [6]. Nevertheless, this figure still exceeds the 20% emergency threshold established by the WHO, placing Indonesia among the countries with a high public health burden from stunting. The UNICEF conceptual framework provides a foundational lens through which stunting is understood as the product of multilayered interactions among socioeconomic, environmental, and maternal and child health determinants across the life cycle [7]. Empirical studies in Indonesia have consistently identified household economic status, sanitation and hygiene conditions, maternal education, and access to health services as key determinants of stunting [8-11]. Evidence further suggests that these socioeconomic determinants continue to exert a strong influence at the subnational and rural level, even as national prevalence trends downward [12].

At the provincial level, West Sulawesi recorded a stunting prevalence of 35.0% based on the 2022 Indonesian Nutrition Status Survey (SSGI), ranking it as the third-highest province nationally. Within this province, Polewali Mandar Regency stands out as one of the primary contributing districts [13-15]. The prevalence distribution further revealed that a large proportion of households in this area were characterised by low to moderate economic status (83.64%), limited sanitation infrastructure, and varying degrees of access to health facilities, underscoring the multidimensional nature of the problem.

The existing body of literature in Indonesia has generated substantial evidence on the determinants of stunting, but this evidence is built almost entirely on a binary outcome framework, comparing stunted against non-stunted children without distinguishing degrees of severity. Badriyah and Syafiq [8] demonstrated that access to adequate sanitation and hygiene was significantly associated with stunting in children under two years in Indonesia. Andreinie et al. [9] confirmed that feeding practices and household socioeconomic conditions were important determinants of stunting status in children aged 6 to 23 months. At the macro level, Hamzah and Sofilda [11] identified socioeconomic indicators and fiscal decentralisation as significant predictors of stunting prevalence across Indonesian districts, while Ataullahjan et al. [12] found that social sector drivers in education, the economy, and sanitation contributed differentially to stunting reduction across regions. Methodologically, Aswi et al. [16] employed Bayesian spatio-temporal modelling to examine socioeconomic factors and spatial patterns of stunting in Indonesia, and Muche et al. [17] applied multilevel Bayesian analysis to identify predictors of stunting among children aged 6 to 59 months in Ethiopia. While these studies have meaningfully advanced understanding of which factors are associated with stunting, their shared reliance on a binary or aggregated outcome means that the extent to which the same determinants operate differently across moderate versus severe stunting information directly relevant to prioritising interventions remains largely undocumented, particularly at the district and rural level in Indonesia [16-18].

A smaller body of international evidence has begun to address this gap by treating stunting severity

as an ordinal outcome. Dewau [19] applied a multilevel ordinal logistic regression model to analyse predictors of severe stunting in Ethiopian children and demonstrated that this approach yielded richer insights than binary analysis by distinguishing factors operating differentially across severity levels. Similarly, Berhanu et al.[20] used an ordinal logistic regression framework to examine the nutritional status of primary school students in Ethiopia, identifying determinants that varied by severity category. In the Indonesian context, Berawi et al. [21] examined the influence of sanitation performance and parental livelihood on stunting severity in South Lampung Regency; however, their analysis did not apply ordinal logistic regression and considered a limited set of socioeconomic determinants within a rural setting. This gap is consequential: severe stunting, defined as HAZ below negative three standard deviations, is associated with a three-fold higher risk of child mortality and significantly greater cognitive deficits than moderate stunting, implying that determinants of severity may warrant differentiated intervention priorities. Despite this, studies applying ordinal logistic regression to examine a comprehensive set of socioeconomic determinants of stunting severity at the district and rural level in Indonesia remain markedly limited.

Taken together, this review indicates that although determinants of stunting in Indonesia have been extensively studied, evidence on how these determinants relate specifically to stunting severity and studies applying ordinal logistic regression to this question in a rural district setting remains scarce. Therefore, this study aims to examine the association between six socioeconomic and access-related determinants (household economic status, maternal education level, latrine ownership, drinking water source, frequency of posyandu visits, and access to health facilities) and stunting severity among children under two years of age in rural Polewali Mandar Regency, using ordinal logistic regression analysis. By estimating determinants across each level of stunting severity rather than collapsing the outcome into a binary category, this study is expected to generate more operationally precise evidence to support differentiated stunting-reduction strategies at the local government level, contributing to the empirical literature on child nutrition determinants in decentralised settings and to the design of targeted interventions in high-burden rural areas of Indonesia.

METHODS

Study design and participants

This study employed a quantitative observational analytic design with a cross-sectional approach, in which the predictor variables (household economic status, maternal education, latrine ownership, drinking water source, posyandu visit frequency, and access to health facilities) and the outcome variable (stunting severity) were measured concurrently at a single point in time. The study was conducted in the Mapilli sub-district of Polewali Mandar Regency, West Sulawesi Province, Indonesia, with data collected in April 2026 and analysed in June 2026.

Polewali Mandar Regency was purposively selected because West Sulawesi recorded the third-highest provincial stunting prevalence in Indonesia (35.0%) according to the 2022 SSGI, with Polewali Mandar identified as a principal contributing district (Ministry of Health of the Republic of Indonesia, 2022; Pemerintah Polewali Mandar, 2023; Kemenko PKM, 2023). Rural areas of the regency were prioritised because preliminary data indicated a stunting prevalence of 46.67% among children under two years, well above the WHO 20% public-health emergency threshold, alongside a predominantly low-to-moderate household economic profile (83.64% of households), limited sanitation infrastructure, and uneven access to health services providing a substantively appropriate setting for examining severity-differentiated determinants of stunting.

The study population comprised all children under two years of age residing in rural households in the Mapilli sub-district, estimated at 580 children based on sub-district health office (Puskesmas) and posyandu registers. Stunting status for each child was determined from secondary anthropometric data extracted from existing Puskesmas growth-monitoring records (detailed in the “outcome variable” subsection below). Socioeconomic and access-related predictor data were

collected separately through household visits: posyandu cadres visited the households of registered children directly to administer the structured questionnaire to the mother or primary caregiver, independent of the child's posyandu attendance status. Cadres and village midwives (bidan desa) attempted to reach all 580 registered households within the one-month data collection period; however, coordination and communication difficulties between village midwives and posyandu cadres in parts of the study area constrained the number of households for which complete data (both anthropometric and socioeconomic) could ultimately be obtained. Every household successfully reached during the field period was enrolled consecutively, yielding a final sample of 165 child-household pairs (28.4% of the target population).

Consecutive enrolment of every household successfully reached, rather than random subsampling from among them, was deliberately adopted as the recruitment strategy for this study. Because stunting severity was modelled as a three-category ordinal outcome, obtaining stable and unbiased proportional-odds estimates required an adequate number of cases within each severity category, particularly the smallest and clinically most critical category, severe stunting, since events-per-category rather than total sample size alone determines the stability of (multinomial/ordinal) logistic regression estimates [22–25]. As severe stunting is a comparatively low-frequency subgroup within the source population, further subsampling within an already time- and coordination-constrained field period would have carried a substantial risk of failing to capture a sufficient number of severe cases by chance alone. Enrolling every household for which complete data could be obtained was therefore adopted to maximise the ascertainment of cases across all severity categories, including severe stunting, consistent with recommended practice for recruiting adequate numbers of a low-frequency subgroup within a time-constrained field setting.

Data collection and measurement

Outcome variable

Stunting severity was the primary outcome variable, operationally defined and classified into three ordered categories based on the height-for-age z-score (HAZ) calculated relative to the WHO Child Growth Standards: not stunted (HAZ ≥ -2 SD, coded 0), moderate stunting (-3 SD $\leq$ HAZ < -2 SD, coded 1), and severe stunting (HAZ < -3 SD, coded 2). Anthropometric measurements (recumbent length, for children aged 0–23 months) were performed by trained nutrition staff/cadres at the Mapilli Sub-district Public Health Centre (Puskesmas) as part of routine growth-monitoring activities. All measuring personnel had completed Indonesia's Ministry of Health standardised anthropometry training, which includes practical standardisation exercises to reduce inter- and intra-observer variability. Length was measured to the nearest 0.1 cm using a length board Kemenkes RI/Benemed PT-613, an instrument that conforms to WHO equipment specifications for recumbent length measurement and is routinely calibrated by Puskesmas staff prior to use.

Because these data were extracted from existing Puskesmas surveillance records rather than measured directly by the research team, formal quantitative inter-observer and intra-observer reliability statistics (e.g., technical error of measurement, TEM) specific to this study's measurement occasions were not available and could not be calculated retrospectively. This is acknowledged as a limitation of relying on secondary anthropometric data and is discussed further in the limitations subsection.

Predictor variables

Six predictor variables were obtained through a structured, interviewer-administered questionnaire adapted from existing, nationally standardised classification instruments rather than newly developed as a new psychometric scale. The questionnaire, comprising 13 items presented in Bahasa Indonesia paper-based or digital/tablet-based administration, was completed through structured interviews with the mother or primary caregiver, conducted by trained Posyandu cadres during household visits, with the following operational definitions: 1) Maternal education level, the highest formal education completed by the mother/primary caregiver, categorised as no schooling, primary (SD), junior secondary (SMP), senior secondary (SMA), or higher education (diploma/university); 2) Household

economic status, assessed through structured interview items covering household head's primary occupation, dwelling ownership and construction materials, and ownership of selected durable assets (e.g., motorcycle, television, mobile phone), following an approach adapted from Indonesia's Family Welfare Classification (*Keluarga Sejahtera*) criteria issued by the National Population and Family Planning Board (BKKBN). A composite score was computed for each household and classified into tertiles corresponding to low (=1), moderate (=2), and high (=3) economic status; 3) Latrine ownership, categorised as no proper latrine (=0) versus proper latrine (=1), where a proper latrine was defined as a private facility with a water-sealed (*leher angsa*) pour-flush design connected to a septic tank or equivalent improved containment system, consistent with Indonesian Ministry of Health sanitation criteria under Permenkes RI No. 3 Tahun 2014 concerning Community-Based Total Sanitation (Sanitasi Total Berbasis Masyarakat, STBM) [22], which specifies a water-sealed pour-flush design connected to a septic tank as a core requirement of a hygienic latrine; 4) Drinking water source, categorised as ineligible/unimproved (=0) versus eligible/improved (=1), following the Indonesian Ministry of Health's drinking-water source eligibility criteria, consistent with the protected/improved water-source classification applied in Indonesia's National Basic Health Research (Riskesdas), following WHO–UNICEF Joint Monitoring Programme (JMP) criteria (piped water, protected well or borehole, protected spring, or rainwater, located more than 10 metres from a contamination source), as currently regulated under Permenkes RI No. 2 Tahun 2023 concerning the Implementing Regulation of Government Regulation No. 66 of 2014 on Environmental Health [23] (which superseded Permenkes No. 492/Menkes/Per/IV/2010); 5) Frequency of posyandu visits, attendance during the 6 months preceding data collection, categorised as never (=0, zero attendance), irregular (=1, attended in 1–3 of the preceding months), or regular (=2, attended in ≥4 of the preceding months), based on posyandu attendance (KMS/growth-card) records cross-checked with caregiver report; and 6) Access to health facilities, caregiver-reported ease of reaching the nearest health facility (Puskesmas/Pustu), categorised as easy (=1, reachable within approximately 30 minutes by the household's usual mode of transport) or difficult (=0, requiring more than 30 minutes, or impeded by distance, terrain, or lack of available transport). The 30-minute travel-time threshold is consistent with cut-offs commonly applied in Indonesian health-access research using Riskesdas data, where households with travel time under 30 minutes have been shown to have significantly higher odds of Puskesmas utilisation than those with longer travel times [24].

Because five of the six variables were single, criterion-referenced items derived directly from established Indonesian Ministry of Health and BKKBN classification standards already validated for the national population, formal item-level validity and reliability testing was not applicable to these individually. Data collection was conducted by trained Posyandu cadres. This study, including its data-collection instruments, was reviewed and approved by the Health Research Ethics Committee of Institut Nani Hasanuddin (Approval No. 1252/INSTITUT-NH/KEPK/IV/2026; Protocol No. SK 674/STIKES-NH/BAU/X/2018; issued 18 April 2026).

Data analysis

Data were processed and analysed using R version 4.3.2 (R Core Team, 2023), with the MASS, brant, and ordinal packages. Descriptive analysis summarised the frequency distribution of the outcome and predictor variables with cross-tabulations. Multicollinearity among predictors was assessed via Spearman's rank correlation matrix, with a threshold of $r > 0.70$ considered indicative of problematic multicollinearity. The proportional odds (parallel regression) assumption was tested using the Brant test at both the omnibus level and per predictor category ($\alpha = 0.05$; Brant, 1990). The Proportional Odds Model (POM) was estimated to obtain regression coefficients, standard errors, Wald z-statistics, and p-values for each predictor (significance level: $\alpha = 0.05$), with effect sizes expressed as odds ratios (OR) and 95% profile-likelihood confidence intervals. Overall model fit was evaluated using the model and null log-likelihoods, the likelihood ratio statistic (G^2), and McFadden's, Cox and Snell's, and Nagelkerke's pseudo-R^2 measures [25-27].

RESULTS

Characteristics of study participants

A total of 165 children under two years of age from rural households in Polewali Mandar Regency, West Sulawesi, were enrolled in this study. The characteristics of the outcome variable and the six predictor variables are summarised in **Table 1**. Of the 165 children, 88 (53.33%) were not stunted, 53 (32.12%) were moderately stunted, and 24 (14.55%) were severely stunted, corresponding to an overall stunting prevalence of 46.67% — more than twice the 20% threshold the WHO designates as a public health emergency. Among sanitation-related variables, 113 households (68.48%) owned a latrine, while 52 (31.52%) did not. Access to safe drinking water was notably high, with 157 households (95.15%) using an eligible water source. The frequency of posyandu (integrated health post) visits showed that 135 mothers (81.82%) attended regularly, 25 (15.15%) attended irregularly, and only 5 (3.03%) had never visited. Access to health facilities was reported as easy by 155 households (93.94%) and difficult by 10 households (6.06%).

For household economic status, 83.64% of households fell into the low-to-moderate stratum (40.00% low, 43.64% moderate), with only 16.36% classified as high income. Among sanitation- and access-related variables, most households owned a proper latrine (68.48%) and used an eligible drinking water source (95.15%); most mothers attended posyandu regularly (81.82%, versus 15.15% irregularly and 3.03% never), and most households reported easy access to health facilities (93.94%).

Consistent with the scope defined in the Methods, only the six socioeconomic and access-related variables described above were collected as predictors in this study. Information on children's exact age in months, sex, dietary or food-intake patterns, and other potential confounding factors (e.g., maternal nutritional status, birth weight, infant feeding practices, or caregiver stress and lifestyle indicators) was not gathered as part of the data-collection protocol and could therefore not be described, examined, or statistically adjusted for in this analysis. This reflects a scope limitation of the original study design rather than an omission in reporting, and is discussed further in the Limitations subsection

Cross-tabulations showed consistent patterns across the predictor variables, although several of these subgroups were small and the corresponding percentages should be read with caution. All eight children (100%) from households with an ineligible drinking water source were stunted, half of them (50.0%) severely; because this subgroup comprised only eight households (4.85% of the sample), this pattern is imprecise. Similarly, all ten children from households with difficult health-facility access were stunted, split evenly between moderate (50.0%) and severe (50.0%) stunting again a small subgroup (6.06% of the sample) for which the estimate is unstable. By comparison, 56.8% of children from households with easy health-facility access were not stunted. Children from high-income households were not stunted more often (77.8%) than those from low-income households (37.9%), and children whose mothers

Table 1. Characteristics of study participants (n = 165)

Characteristic	n	%
Stunting severity		
Not stunted	88	53.33
Moderate stunting	53	32.12
Severe stunting	24	14.55
Maternal education		
No formal schooling	12	7.27
Primary (SD)	52	31.52
Junior secondary (SMP)	25	15.15
Senior secondary (SMA)	53	32.12
Higher education	23	13.94
Household economic status		
Low	66	40.00
Moderate	72	43.64
High	27	16.36
Latrine ownership		
No proper latrine	52	31.52
Proper latrine	113	68.48
Drinking water source		
Ineligible	8	4.85
Eligible	157	95.15
Posyandu visit frequency (preceding 6 months)		
Never	5	3.03
Irregular	25	15.15
Regular	135	81.82
Access to health facilities		
Difficult	10	6.06
Easy	155	93.94

attended posyandu irregularly had a higher proportion of severe stunting (36.0%) than those who attended regularly (10.4%).

Relationships among predictor variables

The Spearman correlation matrix among the six predictor variables showed no problematic multicollinearity: all pairwise correlations remained below the pre-specified threshold of $r > 0.70$. The strongest correlation was between household economic status and latrine ownership ($r = 0.381$) a moderate association consistent with wealthier households more often having better sanitation facilities and it does not compromise the stability of the regression parameter estimates.

Validity of the proportional odds model

Before interpreting the model, the appropriateness of the Proportional Odds Model (POM) was assessed using the Brant test in **Table 2**. The omnibus test yielded a chi-square value of 14.07 (df = 11, p = 0.23), indicating that the global parallel-regression assumption was satisfied at the 5% significance level. At the level of individual coefficients, two categories showed borderline violations: the senior-secondary category of maternal education (p = 0.03) and the irregular-attendance category of posyandu visits (p = 0.02). The Brant test can behave unpredictably under sparse-data conditions, as reflected in the software warning that 994 cell combinations were unobserved. Because the omnibus test the criterion most relevant at the global model level was not significant, the POM was retained, with the caveat that the two flagged coefficients warrant additional caution in interpretation.

Predictors of stunting severity

Table 3 presents the parameter estimates, standard errors, and p-values for the ordinal logistic regression model. The model's log-likelihood improved from −161.777 (null model) to −135.119, yielding a likelihood ratio statistic of $G^2=53.315$ (df=11, $p<0.001$) and indicating that the predictor set was collectively associated with a significant share of the variation in stunting severity. Pseudo-R^2 values were McFadden $R^2 = 0.165$, Cox–Snell $R^2 = 0.276$, and Nagelkerke $R^2 = 0.321$.

Four predictors were significantly associated with stunting severity ($\alpha = 0.05$). Household economic status at the moderate level ($\beta = 0.786$, $p = 0.035$) and the high level ($\beta = 1.624$, $p = 0.007$) was associated with higher cumulative log-odds of being in a lower stunting severity category, relative to the low-income reference. Access to an ineligible drinking water source ($\beta = -1.717$, $p = 0.021$), irregular posyandu attendance ($\beta = -1.045$, $p = 0.024$), and difficult health facility access ($\beta = -3.046$, $p < 0.001$) were each associated with lower log-odds of being in a lower severity category, corresponding to a higher likelihood of more severe stunting.

Magnitude of associations for significant predictors

Table 4 presents odds ratios (OR) and 95% profile-likelihood confidence intervals for the four statistically

Table 2. Brant test results for the proportional odds assumption

Parameter	Chi-Square	df	p-value	Decision
Omnibus	14.07	11	0.23	PRA satisfied
Maternal education: primary (SD) vs higher	1.55	1	0.21	PRA satisfied
Maternal education: senior secondary (SMA) vs higher	4.89	1	0.03*	PRA violated
Maternal education: junior secondary (SMP) vs higher	0.00	1	0.99	PRA satisfied
Maternal education: no schooling vs higher	2.16	1	0.14	PRA satisfied
Household economic status: moderate vs low	0.01	1	0.92	PRA satisfied
Household economic status: high vs low	0.15	1	0.7	PRA satisfied
Latrine ownership: no vs yes	0.01	1	0.92	PRA satisfied
Drinking water source: ineligible vs eligible	0.00	1	0.96	PRA satisfied
Posyandu visits: never vs regular	0.06	1	0.81	PRA satisfied
Posyandu visits: irregular vs regular	5.56	1	0.02*	PRA violated
Health facility access: difficult vs easy	0.00	1	0.99	PRA satisfied

Table 3. Ordinal logistic regression parameter estimates for stunting severity among children under two years in rural Polewali Mandar (n = 165)

Parameter	Coefficient (β)	Std. Error	t-value	p-value
Maternal education: primary (SD) vs higher	−0.843	0.582	−1.449	0.147
Maternal education: senior secondary (SMA) vs higher	−0.637	0.571	−1.115	0.265
Maternal education: junior secondary (SMP) vs higher	0.882	0.730	1.208	0.227
Maternal education: no schooling vs higher	0.010	0.887	0.012	0.991
Household economic status: moderate vs low	0.786	0.373	2.107	0.035*
Household economic status: high vs low	1.624	0.602	2.695	0.007**
Latrine ownership: no vs yes	0.501	0.388	1.292	0.196
Drinking water source: ineligible vs eligible	−1.717	0.744	−2.308	0.021*
Posyandu visits: never vs regular	−0.779	0.849	−0.918	0.358
Posyandu visits: irregular vs regular	−1.045	0.465	−2.250	0.024*
Health facility access: difficult vs easy	−3.046	0.782	−3.895	<0.001***
Intercept 1|2	−2.319	0.622	−3.727	<0.001***
Intercept 2|3	−0.154	0.583	−0.264	0.792

*p < 0.05; **p < 0.01; ***p < 0.001

Table 4. Odds ratios and 95% profile-likelihood confidence intervals for statistically significant predictors

Parameter	OR	95% CI Lower	95% CI Upper
Economic status: moderate vs low	2.194	1.063	4.605
Economic status: high vs low	5.072	1.628	17.679
Drinking water: ineligible vs eligible	0.180	0.038	0.744
Posyandu visits: irregular vs regular	0.352	0.140	0.877
Health facility access: difficult vs easy	0.048	0.009	0.208

significant predictors. Household economic status showed a graded association with stunting severity. Children from moderate-income households were associated with 2.19 times greater odds of being in a lower stunting severity category than those from low-income households (OR = 2.194; 95% CI: 1.063–4.605), and this association was stronger among high-income households (OR = 5.072; 95% CI: 1.628–17.679); the wide confidence interval for the high-income estimate reflects the relatively small number of high-income households in the sample (n = 27) and calls for cautious interpretation. Children from households with an ineligible drinking water source were associated with 82.0% lower odds of being in a lower stunting severity category (OR = 0.180; 95% CI: 0.038–0.744); because only eight households (4.85%) fell into this category, this estimate is imprecise and should be interpreted with caution, as it may be unstable. Irregular posyandu attendance was associated with 64.8% lower odds of being in a lower stunting severity category compared with regular attendance (OR = 0.352; 95% CI: 0.140–0.877). The strongest association was observed for difficult health facility access (OR = 0.048; 95% CI: 0.009–0.208), corresponding to 95.2% lower odds of being in a lower stunting severity category; given the small number of households with difficult access (n = 10), this estimate also carries a wide confidence interval and should be interpreted cautiously, as it too may be unstable.

DISCUSSION

This study applied ordinal logistic regression to examine the socioeconomic and environmental determinants of stunting severity among 165 children under two in rural Polewali Mandar Regency, West Sulawesi, Indonesia. The approach moves beyond conventional binary analyses by treating stunting as a three-category ordinal outcome not stunted, moderately stunted, and severely stunted thereby generating more granular evidence to inform differentiated intervention strategies. Four variables were identified as statistically

significant determinants of stunting severity: household economic status, drinking water source eligibility, posyandu visit frequency, and health facility access. The findings are discussed below in relation to the existing empirical literature and their implications for public health policy at the local government level.

Household economic status

The association between household economic status and stunting severity was among the most pronounced findings in this study, with a clear gradient across income strata. Compared to low-income households, children from moderate-income families had approximately 2.19 times greater odds of being in a lower stunting severity category, while those from high-income families had 5.07 times greater odds of being in a lower stunting severity category, relative to low-income households. These findings are broadly consistent with the established literature identifying household socioeconomic status as an important determinant of child malnutrition. Andreinie et al. [9] demonstrated that household socioeconomic conditions were among the most important predictors of stunting among Indonesian children aged 6 to 23 months, and Hamzah and Sofilda [11] confirmed that socioeconomic indicators were significant predictors of stunting prevalence across Indonesian districts.

At the macro-analytical level, Fikru and Van Doorslaer [3] examined socioeconomic differences in stunting across low- and middle-income countries and found that income-related differences in stunting persisted even as average prevalence declined, a pattern broadly consistent with the concentration of stunting among lower-income households observed in the present sample from Polewali Mandar. Huda et al. [4] similarly identified household wealth as a structural determinant of stunting in South Asia, underscoring the cross-contextual relevance of this finding. The graded pattern observed here moderate economic status associated with lower stunting severity and high economic status associated with markedly lower stunting severity suggests that interventions targeting economic vulnerability, such as conditional cash transfers, livelihood enhancement programmes, and targeted food supplementation, may be a useful component of stunting reduction strategies in this district. The comparatively wide confidence interval for the high-income OR (1.628–17.679) reflects the small proportion of high-income households (16.36%) and warrants cautious interpretation, but does not diminish the substantive significance of the overall economic gradient.

Drinking water source

Access to eligible drinking water was significantly associated with lower stunting severity (OR = 0.180; 95% CI: 0.038–0.744). Children from households reliant on ineligible water sources faced an 82.0% reduction in the odds of being in a lower stunting severity category, underscoring the profound health burden associated with contaminated water access in this rural context. This finding resonates strongly with Badriyah and Syafiq [8], who documented a significant association between inadequate sanitation and hygiene including water quality and stunting among Indonesian children under two years of age. A plausible pathophysiological pathway has been described in the literature: contaminated drinking water is thought to facilitate transmission of enteric pathogens causing recurrent gastrointestinal infections, which may compromise nutrient absorption and divert metabolic resources from growth, consistent with the manifestation of stunting [4].

The descriptive patterns in this study are consistent with this proposed mechanism: all eight children (100%) residing in households with ineligible water sources were stunted, and half of them were severely stunted. Although the small number of households with ineligible water sources (n = 8, 4.85%) limits generalisation, the magnitude and direction of the association are clinically meaningful. The finding aligns with UNICEF's conceptual framework, which situates water, sanitation, and hygiene (WASH) conditions as proximal environmental determinants of child nutritional status. These results reinforce the need for targeted WASH interventions in rural Polewali Mandar, particularly among households still reliant on unprotected springs, rivers, or other non-piped sources.

Posyandu visit frequency

Irregular posyandu attendance was associated with greater odds of more severe stunting compared

to regular attendance (OR = 0.352; 95% CI: 0.140–0.877), consistent with the theoretical expectation that posyandu services serve as a critical contact point for early detection and management of growth faltering. The posyandu system in Indonesia provides integrated child health services including growth monitoring, immunisation, micronutrient supplementation, and nutritional counselling, which collectively support optimal child development during the first thousand days of life [9]. Regular engagement with posyandu services is thought to support timely identification of at-risk children and may facilitate referral to higher-level health care facilities when necessary.

An apparent paradox was observed in the descriptive data: among children whose mothers never attended posyandu, the proportion with severe stunting was lower than among irregular attenders. This counterintuitive pattern likely reflects selection effects or the very small cell size of the never-attended group (n = 5), which precluded meaningful statistical comparison. The regression model, adjusting for other covariates, appropriately yielded a non-significant result for this category (p = 0.358), reinforcing that the never-visited group should not be interpreted at face value. The significant association between regular versus irregular attendance and stunting severity remains the most robust finding in this subgroup, consistent with evidence from Dewau [19] that community-level health service utilisation is associated with reduced stunting severity. The borderline Brant test result for the irregular attendance variable suggests that future studies with larger samples should consider partial proportional odds models or multinomial logistic regression as robustness checks.

Health facility access

Difficult access to health facilities was the strongest predictor of stunting severity in the model (OR = 0.048; 95% CI: 0.009–0.208), corresponding to 95.2% lower odds of being in a lower stunting severity category. This finding is striking in its magnitude and has important policy implications. Children from households with difficult health facility access were exclusively stunted all 10 children (100%) in this group experienced either moderate (50%) or severe (50%) stunting, with no non-stunted child observed. While the small group size (n = 10) again requires interpretive caution, the absolute absence of non-stunted children in this category lends credence to the finding's direction and substantive importance.

Health facilities serve as the principal delivery platform for nutrition-specific interventions, including iron-folic acid supplementation for pregnant women, exclusive breastfeeding promotion, complementary feeding counselling, and management of acute malnutrition. When geographic, economic, or infrastructural barriers prevent families from accessing these services, the cumulative deficit in preventive and curative care may be associated with conditions conducive to severe growth faltering. Adrizain et al. [10] identified access to health services as a key structural determinant of stunting in Indonesian children, and the present findings are consistent with this at the severity level. The dramatic OR observed in this study may also partially reflect a confounding relationship between difficult access and poverty, as remote rural households tend to be both geographically disadvantaged and economically marginalised a limitation that future studies with richer covariate measurement should address through mediation analyses.

Non-significant variables: maternal education and latrine ownership

Maternal education level and latrine ownership did not reach statistical significance in the regression model. The non-significance of maternal education is somewhat divergent from the broader literature, which generally identifies maternal education as an important determinant of child nutritional status [4,12]. However, several contextual factors may explain this finding. First, the distribution of maternal education in this sample was moderately concentrated at the secondary level (SMA: 32.12%), with relatively few mothers at the educational extremes, potentially attenuating the detectable gradient. Second, the cross-tabulation data did suggest a partial association for senior secondary educated mothers, but this was insufficient to achieve significance after adjustment for other covariates. The borderline Brant

test violation for the SMA category also suggests unstable proportional odds for this variable, warranting interpretation with caution.

Latrine ownership similarly did not achieve significance ($p = 0.196$), despite theoretical expectations linking open defaecation to faecal-oral pathogen transmission and child growth faltering. The finding may reflect the comparatively high latrine ownership rate in this sample (68.48%), which reduced statistical variability and the ability to detect a significant effect. Furthermore, latrine ownership as a binary indicator does not capture the quality of sanitation infrastructure or actual usage behaviour, which are more proximal determinants of hygiene-related disease burden. Future studies should consider incorporating composite WASH indices or behavioural measures of sanitation practice to more sensitively capture this dimension.

Methodological considerations

The use of ordinal logistic regression in this study provides methodological advantages over conventional binary approaches that aggregate moderate and severe stunting into a single outcome category. By modelling stunting severity as an ordered three-category variable, this study could differentiate the magnitude and direction of covariate associations across severity thresholds, yielding more operationally precise evidence for policy targeting. This approach is consistent with the recommendations of Dewau [19] and Berhanu et al. [20], who demonstrated the analytical value of ordinal frameworks in nutritional epidemiology. The Proportional Odds Model was validated through the Brant omnibus test, and the model's explanatory power Nagelkerke $R^2 = 0.321$ indicates that the predictor set accounted for approximately one-third of the variance in stunting severity, a reasonable performance for a community-based cross-sectional study in a data-constrained setting.

This study has several notable strengths that merit consideration alongside its limitations. First, to the best of the authors' knowledge, this is among the first studies in the Indonesian district and rural context to model stunting severity as a three-category ordinal outcome using proportional odds ordinal logistic regression, rather than relying on the conventional binary stunted/not-stunted classification used in most prior national and subnational studies; this approach generated more operationally granular evidence that distinguishes moderate from severe stunting, directly supporting risk-stratified intervention prioritisation at the sub-district level. Second, although a non-probability design, the consecutive sampling strategy was deliberately chosen to maximise the ascertainment of severe stunting a comparatively rare but clinically critical subgroup within a time constrained one-month field period, consistent with recommended practice for recruiting adequate numbers of low-frequency subgroups in ordinal/multinomial outcome modelling. Third, the appropriateness of the Proportional Odds Model was not assumed but formally verified through the Brant test at both the omnibus and per-predictor level, and multicollinearity among predictors was assessed via Spearman's correlation matrix prior to model fitting, lending methodological rigour and transparency to the analytic approach. Fourth, all predictor variables were operationalised using nationally standardised classification criteria for example, the BKKBN Family Welfare Classification for household economic status and the Indonesian Ministry of Health's criteria for drinking-water eligibility and latrine adequacy and anthropometric measurements were obtained by Ministry of Health-trained personnel using calibrated instruments within routine Puskesmas surveillance, supporting measurement consistency and comparability with national policy benchmarks. Finally, by focusing on a high-burden rural sub-district rarely captured in national or provincial-level surveys, this study generated locally contextualised evidence with direct relevance for district-level stunting-reduction planning, addressing a persistent gap between national prevalence estimates and the sub-national determinants that shape local intervention design.

Nonetheless, several limitations should also be acknowledged. First, the cross-sectional design precludes causal inference, and temporal relationships between predictors and stunting outcomes cannot be established. Second, the consecutive sampling strategy anchored to posyandu attendance points constitutes a non-probability design that may have introduced coverage bias by under-

representing children with irregular or absent posyandu attendance, precisely the subgroup hypothesised to be at elevated risk of severe stunting. This is consistent with the markedly small and statistically anomalous "never attended" cell (n = 5) observed in this sample, and may have biased the posyandu-attendance effect estimate toward the null; future studies should draw the sampling frame from a complete administrative register (e.g., e-PPGBM or Puskesmas birth/growth registers covering all 580 eligible children in the sub-district) combined with active household tracing for non-attenders, to mitigate this source of bias.

Third, the achieved sample of 165 children, representing 28.4% of the estimated 580 eligible children in Mapilli sub-district, yields an estimation precision of approximately ±6.8% for the observed stunting prevalence slightly below the conventional 5% benchmark. More critically for the regression model, the events-per-variable (EPV) ratio for the smallest outcome category (severe stunting, n = 24) relative to the 11 estimated parameters was approximately 2.2, substantially below the minimum EPV of 10 generally recommended for stable logistic model estimation. This low EPV, compounded by sparse cells for ineligible drinking water (n = 8) and difficult health facility access (n = 10), inflated standard errors and produced wide confidence intervals for several key estimates (e.g., high-income status OR 95% CI: 1.628–17.679; health facility access OR 95% CI: 0.009–0.208), and may indicate partial quasi-separation in the data. Penalised estimation approaches (e.g., Firth's bias-reduced logistic regression) or partial proportional odds models particularly for the maternal education (SMA) and irregular posyandu attendance categories, which showed borderline Brant test violations should be applied as sensitivity analyses in future replications with larger samples.

Fourth, the study area is geographically limited to rural Polewali Mandar Regency, and findings may not generalise to urban settings or other provinces with different socioeconomic and infrastructural profiles. Finally, residual confounding from unmeasured variables including dietary intake diversity, infant feeding practices, maternal anthropometry, and birth spacing cannot be excluded.

CONCLUSIONS

Stunting prevalence was 46.67% (32.12% moderate, 14.55% severe), exceeding the WHO public health emergency threshold. Four variables were significantly associated with stunting severity: household economic status (moderate OR = 2.194; high OR = 5.072), drinking water source eligibility (OR = 0.180), posyandu visit frequency (OR = 0.352), and health facility access (OR = 0.048), while maternal education and latrine ownership were not statistically significant. Given the small number of households with ineligible drinking water and difficult health facility access, these estimates should be interpreted with caution.

As this was a cross-sectional study, these findings represent associations rather than causal relationships. They nonetheless suggest that interventions addressing household economic vulnerability, expanding access to eligible drinking water, strengthening regular posyandu attendance, and improving access to health facilities may be relevant components of stunting-reduction strategies in Polewali Mandar and similar rural, high-burden districts, pending confirmation from further research. Future studies employing longitudinal designs, larger and more representative samples, and expanded covariate measurement (e.g., dietary intake, infant feeding practices, maternal anthropometry, and birth spacing) are needed to confirm these associations and more precisely inform the design of targeted interventions.

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Author contribution

SM.: conceptualization, methodology, investigation, project administration, resources, data curation, formal analysis, visualization, writing—original draft, writing—review and editing; UWA.: investigation, data collection; NA.: investigation, data collection; AI.: investigation, field data collection; ASKH.: investigation, field data collection. All authors reviewed and approved the final manuscript.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the conduct of this research, data analysis, writing of the manuscript, or the publication of this article.

Use of artificial intelligence (AI)

The authors used artificial intelligence (AI) tools solely to assist with language editing, including improving grammar, clarity, and readability of the manuscript. All scientific content, analyses, interpretations, and conclusions were developed and verified by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the final manuscript.

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