Socioeconomic and Maternal Predictors of Toddler Malnutrition: Evidence From Rural Indonesia

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Abstract

Deli Serdang Regency in North Sumatra remains a priority area for malnutrition interventions due to persistent socioeconomic disparities, under-resourced rural health systems, and chronic food insecurity. Although national data (Riskesdas 2018) report a stunting prevalence of 21.3%, localized health surveillance in villages such as Tanjung Anom indicates rates exceeding 30%, highlighting elevated nutritional risk among toddlers. A matched case-control study was conducted involving 64 toddlers aged 12–59 months (32 malnourished, 32 well-nourished), matched 1:1 by age group and gender. Malnutrition was defined according to WHO anthropometric Z-scores (< -2 SD for weight-for-age or height-for-age). Data collection included direct anthropometric measurement and structured maternal interviews, incorporating a 24-hour dietary recall. Conditional logistic regression was employed to account for matching, and standardized protocols were implemented to minimize selection and information bias. After adjusting for confounders, four key risk factors were significantly associated with malnutrition: poor maternal nutritional knowledge (adjusted OR = 3.91; 95% CI: 1.18–12.95; p = 0.026), low household income (aOR = 10.23; 95% CI: 2.00–52.39; p = 0.005), recent infectious disease (aOR = 6.11; 95% CI: 1.79–20.84; p = 0.004), and insufficient food intake (aOR = 72.30; 95% CI: 12.98–402.61; p < 0.001). The wide confidence interval for dietary intake reflects limitations in sample size and variability in exposure. This study is among the first matched case-control investigations in rural North Sumatra to quantitatively link maternal nutrition knowledge with child nutritional status using localized data and WHO standards. The findings underscore the need for targeted, nutrition-sensitive interventions, including strengthening Community Health Post (Posyandu) services, enhancing maternal nutrition education, promoting community home gardens, and improving rural health infrastructure. This model offers potential for scale-up through multisectoral collaboration and context-specific policy adaptation

Keywords: *Malnutrition, toddlers, maternal knowledge, food intake, infectious disease, Deli Serdang, nutrition-sensitive policy*

INTRODUCTION

Malnutrition remains one of the most persistent and complex public health challenges globally, particularly in low- and middle-income countries (LMICs). It impairs physical growth, cognitive development, and long-term human capital formation, perpetuating cycles of poverty and vulnerability (Escher et al., 2024; Rahut et al., 2024). Despite global efforts to improve maternal and child nutrition, progress has been uneven. Recent data indicate that approximately one in four children under the age of five worldwide is stunted, with millions more wasted or underweight (UNICEF et al., 2023). The emergence of the "double burden of malnutrition", the coexistence of undernutrition and rising rates of overweight and obesity, has

further complicated nutrition responses, particularly in LMICs undergoing rapid nutritional transitions (Blankenship et al., 2020; Nguyen et al., 2020).

This dual crisis reflects both structural inequality and rapidly shifting food environments. Fragile food systems, poor sanitation, and limited health services contribute to undernutrition, while increased access to ultra-processed foods drives rising rates of overweight. In South and Southeast Asia, improving child feeding practices, maternal nutrition, and household sanitation has emerged as a priority to curb stunting and wasting (Sulistyaningsih et al., 2024). Nutrition-sensitive interventions, those that address underlying social determinants such as caregiving, food security, and hygiene, have shown promise when integrated with targeted nutrition-specific strategies (Escher et al., 2024).

Indonesia reflects these global dynamics. Nationally, the stunting rate declined significantly from 37.6% in 2013 to 21.6% in 2022, driven by increased policy attention and multisectoral programming (Indonesian Ministry of Health, 2023). However, this progress masks pronounced geographic disparities. The 2023 Indonesian Health Survey still reports a stunting rate of 21.5%, with rural provinces such as North Sumatra exhibiting persistent rates that parallel the national average. Localized data from Tanjung Anom Village in Deli Serdang Regency reveal that 1.3% of toddlers are acutely malnourished, based on WHO weight-for-age Z-scores below −2 SD. While seemingly modest, this figure conceals deeper structural vulnerabilities: income volatility from seasonal agriculture, inadequate access to healthcare, and low maternal education levels intersect to elevate nutritional risk (Desmawati et al., 2025; Laksono et al., 2024).

The 2020 UNICEF Conceptual Framework for Malnutrition provides a robust lens for understanding these dynamics, categorizing causal factors as immediate (e.g., poor dietary intake and illness), underlying (e.g., household food insecurity and inadequate care), and basic (e.g., poverty and lack of education). Among these, maternal nutritional knowledge is increasingly recognized as a modifiable determinant with significant downstream effects. Maternal understanding of child feeding, hygiene, disease prevention, and service utilization is strongly associated with improved child nutrition outcomes, particularly in resource-constrained rural settings (Firdaus & Maulana, 2025; Sulistyaningsih et al., 2024).

In Tanjung Anom, formal health outreach remains limited, leaving gaps in maternal knowledge that may exacerbate structural disadvantages. In contrast, urban centers such as Jakarta and Bandung benefit from higher educational attainment and more robust health infrastructure, both of which correlate with lower malnutrition rates (Saito & Kondo, 2023). Rural communities face not only higher poverty rates and limited infrastructure but also

cultural barriers, including traditional feeding taboos and gendered norms surrounding caregiving (Arifuddin, 2023). While Indonesia's national nutrition strategy articulates a strong multisectoral vision aligned with the Sustainable Development Goals (SDGs 2, 3, and 4), many of its operational components remain insufficiently tailored to local realities, particularly in rural provinces (Jokhu & Syauqy, 2024; Nguyen et al., 2020).

Although several studies have explored the structural determinants of malnutrition in Indonesia, most rely on national surveys or broad regional analyses, which may obscure nuanced local dynamics. Few have empirically examined how maternal nutritional knowledge interacts with key risk domains, economic insecurity, dietary adequacy, and recent infectious disease exposure, at the village level. This study addresses that critical gap by employing a matched case-control design in Tanjung Anom Village, North Sumatra, an area with documented nutritional vulnerability but limited empirical investigation. By controlling for child age and gender, the design isolates the contribution of maternal knowledge while accounting for economic and health-related.

This is the first matched case-control study to link maternal nutritional knowledge with child nutritional outcomes in rural North Sumatra, using WHO child growth standards (WHO, 2023). The study's integrative approach, considering behavioral, economic, and environmental risk factors, enables a granular understanding of how maternal knowledge can mitigate or amplify structural disadvantages. The findings have direct policy relevance, underscoring the importance of strengthening *Posyandu*-based nutrition counseling, expanding conditional cash transfer schemes, and enhancing infection control measures. More broadly, this work supports Indonesia's multisectoral nutrition efforts by providing local-level evidence to inform targeted interventions and help close the gap between policy design and implementation.

METHODS

This study employed a matched case–control design to identify risk factors associated with clinically diagnosed malnutrition among toddlers, a relatively rare outcome in population-based research. The study was conducted between September and October 2023 in Tanjung Anom Village, Deli Serdang Regency, North Sumatra Province, Indonesia, a rural community known for its persistent malnutrition burden despite national improvements in child nutrition indicatorsThe study included toddlers aged 12–59 months, with a total sample of 64 children: 32 malnourished cases and 32 well-nourished controls. The sample size was determined using effect sizes from prior studies, based on a 95% confidence level, 80% statistical power, and a minimum detectable odds ratio (OR) of 3.0 for primary exposure variables such as maternal

nutritional knowledge and household income (Muliani et al., 2023; Pradigdo et al., 2025). A 1:1 matching ratio was applied according to gender and age group (12–26, 27–42, and 43–59 months) to control for confounding effects. Cases and controls were identified using records from integrated community health posts (*Posyandu*), a widely used platform for maternal and child health monitoring in Indonesia (Aisyah & Widyastuti, 2025; Masthalina et al., 2025). Controls were randomly selected from children with normal nutritional status and individually matched to each case.

Data were collected using multiple methods. Anthropometric measurements were conducted by trained personnel following standardized protocols, and nutritional status was determined using WHO Anthro software. Dietary intake was assessed through a 24-hour recall, cross-verified with a Food Frequency Questionnaire (FFQ) adapted for Indonesian toddlers. Maternal nutritional knowledge was evaluated using a validated, structured 15-item questionnaire tailored to rural contexts. The primary outcome variable was toddler nutritional status, defined as weight-for-age (WAZ) and/or height-for-age (HAZ) Z-scores below −2 SD, in accordance with WHO standards. Independent variables included maternal nutritional knowledge, household income, dietary intake, and recent infectious disease history, with maternal education and household size treated as potential confounders. Data analysis was conducted using SPSS version 25. Descriptive statistics were used to summarize demographic and exposure variables, while Chi-square tests assessed bivariate associations. Conditional logistic regression was employed for multivariable analysis to estimate adjusted odds ratios (aORs) and 95% confidence intervals (CIs). Multicollinearity was assessed using variance inflation factors (VIFs), all of which were below 2.0. Ethical clearance was obtained from the Health Research Ethics Committee of Sekolah Tinggi Ilmu Kesehatan Columbia Asia (Approval No. 002/KEPK/STIKes_CA/2025), along with authorization from the local health authority. Written informed consent was secured from all caregivers after they were fully briefed on the study's objectives, procedures, confidentiality safeguards, and their voluntary right to participate.

RESULTS

Demographic Characteristics

A total of 64 toddlers were enrolled in this study, consisting of 32 malnourished (case group) and 32 well-nourished (control group) children. Most participants were in the 43–59 months age group (50.0%), and the gender distribution showed a higher proportion of females (56.4%). Mothers were predominantly aged 28–33 years, with a majority (62.5%) having

completed only elementary education. Regarding occupation, 79.7% of mothers worked as farmers, while the remainder were housewives or civil servants. Multivariable logistic regression analysis identified four key risk factors significantly associated with malnutrition among toddlers.

Table 1. Demographic Characteristics of Respondents by Nutritional Status (n = 64)

Characteristic	Cases (n = 32)	Controls (n = 32)	p-value
Gender			0.602
Male	15 (46.9%)	13 (40.6%)	
Female	17 (53.1%)	19 (59.4%)	
Age Group (months)			0.848
12–26	8 (25.0%)	7 (21.9%)	
27–42	9 (28.1%)	8 (25.0%)	
43–59	15 (46.9%)	17 (53.1%)	
Mother's Education			0.004
Elementary	26 (81.2%)	14 (43.8%)	
Junior High	3 (9.4%)	6 (18.8%)	
Senior High	1 (3.1%)	5 (15.6%)	
Diploma/Bachelor	2 (6.3%)	7 (21.8%)	
Mother's Occupation			0.028
Farmer	29 (90.6%)	22 (68.8%)	
Housewife	2 (6.2%)	8 (25.0%)	
Civil Servant	1 (3.1%)	2 (6.2%)	

Initial bivariate analysis identified four key risk factors significantly associated with toddler malnutrition: poor maternal nutritional knowledge, low household income, recent infectious disease, and insufficient food intake. Children whose mothers had poor nutritional knowledge were nearly four times more likely to be malnourished compared to those whose mothers had adequate knowledge (adjusted OR = 3.91; 95% CI: 1.18–12.95; p = 0.026). Low household income was also strongly associated with malnutrition; toddlers from low-income families had over ten times the odds of being malnourished compared to those from households above the national poverty line (adjusted OR = 10.23; 95% CI: 2.00–52.39; p = 0.004). Recent infectious disease history emerged as another significant determinant. Children who had experienced illnesses such as diarrhea or respiratory infections within the past three months were six times more likely to be malnourished (adjusted OR = 6.11; 95% CI: 1.79–20.84; p = 0.003). The most pronounced association was observed with insufficient food intake. Toddlers who consumed less than 80% of their recommended daily caloric and nutrient intake had a dramatically elevated risk of malnutrition (adjusted OR = 72.30; 95% CI: 12.98–402.61; p < 0.001).

However, this result should be interpreted with caution due to the wide confidence interval, which may reflect sparse data or variability within the sample. These findings suggest

that maternal knowledge, economic status, recent illness, and dietary adequacy all play critical roles in shaping child nutritional outcomes in rural communities such as Tanjung Anom.

Table 2. Bivariate Analysis of Risk Factors Associated with Toddler Malnutrition (n = 64)

Risk Factor	Cases (n = 32)	Controls (n = 32)	Crude OR [95% CI]	p-value
Poor Maternal Knowledge	26 (81.2%)	16 (50.0%)	4.33 [1.36–13.82]	0.014
Low Household Income	30 (93.7%)	18 (56.2%)	11.67 [2.39–57.10]	0.001
Recent Infectious Disease	27 (84.4%)	14 (43.7%)	6.94 [2.08–23.16]	0.002
Insufficient Food Intake	30 (93.6%)	5 (15.6%)	81.00 [12.35–531.29]	<0.001

After adjusting for maternal education, household size, and other potential confounders, all four factors remained significantly associated with malnutrition.

Table 3. Multivariable Logistic Regression of Risk Factors (n = 64)

Risk Factor	Adjusted OR [95% CI]	p-value
Poor Maternal Knowledge	3.91 [1.18–12.95]	0.026
Low Household Income	10.23 [2.00–52.39]	0.004
Recent Infectious Disease	6.11 [1.79–20.84]	0.003
Insufficient Food Intake	72.30 [12.98–402.61]	<0.001

Toddlers whose mothers had poor nutritional knowledge were nearly four times more likely to be malnourished compared to those whose mothers had adequate knowledge. Low income households faced a tenfold increase in malnutrition risk. Similarly, toddlers who had recently experienced infectious diseases had six times the odds of being malnourished. The strongest association was observed with insufficient food intake, which increased the odds of malnutrition more than 70 fold though this finding should be interpreted with caution due to the wide confidence interval, suggesting sparse-data bias. These results affirm that behavioral, economic, and health-related factors interact synergistically to shape child nutrition outcomes in rural areas such as Tanjung Anom. The effect sizes are clinically significant and highlight urgent priorities for intervention.

DISCUSSION

This study sheds light on the complex and interdependent factors driving toddler malnutrition in Tanjung Anom Village, a rural agrarian community in North Sumatra. Agricultural income in this area is not only low but also unstable, fluctuating with planting and harvest cycles and leaving families vulnerable to seasonal food shortages. A significant proportion of the population relies on agricultural output for sustenance; however, this income does not ensure consistent access to nutritious food throughout the year. These fluctuations,

coupled with limited access to diverse food sources, exacerbate nutritional risks for young children and contribute to persistently high rates of undernutrition (Bhutta et al., 2023).

Maternal education levels are generally low in Tanjung Anom, which significantly limits caregivers' ability to access, interpret, and apply nutrition-related information effectively. Low maternal education is frequently associated with poor nutritional practices, as caregivers may lack knowledge of age-appropriate feeding and complementary nutrition, ultimately contributing to suboptimal child growth and development. This limitation is further compounded by limited awareness of nutritional practices that could mitigate malnutrition risks in children (Nguyen et al., 2022; Saputra et al., 2021).

Health infrastructure in Tanjung Anom is limited, with only one midwife serving approximately 200 toddlers, a ratio that makes consistent and personalized care exceedingly difficult. Inadequate health facilities and the limited reach of health services further exacerbate malnutrition rates, as many families lack access to essential health interventions and preventive care (Sinuon et al., 2020). The absence of adequate maternal and child health services also impedes the early identification and treatment of malnutrition, resulting in delays in addressing nutritional deficiencies that could otherwise be mitigated through timely interventions (WHO, 2023).

Geographic isolation and poor transportation infrastructure significantly restrict residents' access to *Puskesmas Pembantu* (sub-health centers village-level facilities that support the main community health center) and markets offering a variety of nutrient-rich foods. The local diet is heavily reliant on staple crops such as rice and cassava, with limited incorporation of high-quality protein and micronutrient-rich foods. This dietary limitation contributes to insufficient nutrient intake and places children at heightened risk of malnutrition, particularly in the absence of dietary diversity (Nguyen et al., 2022). The study's findings underscore the role of food systems in rural areas, where limited access to diverse foods exacerbates the malnutrition burden (Smith & Adams, 2021).

Cultural feeding practices play a critical role in shaping children's nutritional outcomes. In Tanjung Anom, a prevalent custom involves introducing bananas as a first food for infants, which frequently results in the premature cessation of exclusive breastfeeding. This practice, compounded by limited awareness of appropriate infant feeding guidelines, heightens the risk of malnutrition among young children. The early introduction of solid foods such as bananas may lead to nutritional imbalances and missed opportunities for exclusive breastfeeding, which is vital for optimal infant growth and development (Nguyen et al., 2022). These culturally

embedded practices contribute to a high-risk environment for malnutrition, exposing children to both dietary deficiencies and inadequate access to healthcare services (UNICEF et al., 2023).

Aligned with the UNICEF Conceptual Framework for Malnutrition (2020), this study identified insufficient food intake and poor maternal nutritional knowledge as the strongest predictors of malnutrition in toddlers, followed by low household income and recent infectious disease. The convergence of these determinants reflects a deeply systemic issue that demands integrated, multi-sectoral interventions. Malnutrition in this rural community is not solely attributable to inadequate food availability, but is driven by a constellation of interrelated factors including economic hardship, limited maternal knowledge, and restricted access to healthcare services. These challenges are frequently compounded by seasonal and structural vulnerabilities that further erode the resilience of rural households to nutritional risks (WHO, 2023; Apriliani, 2025). The findings underscore the urgency of addressing both the immediate and underlying causes of malnutrition through comprehensive strategies. Recommended interventions include nutrition education, enhancements to healthcare infrastructure, and policies aimed at alleviating the economic vulnerabilities faced by affected families (Bhutta et al., 2023).

Integrating educational initiatives with conditional cash transfers through *Program Keluarga Harapan* (PKH) can help address both behavioral and economic barriers to adequate child nutrition. Indonesia's Family Hope Program (*Program Keluarga Harapan*, PKH) is a conditional cash transfer initiative designed to reduce poverty and improve human capital outcomes among low-income families. As a social protection program, PKH has the potential to alleviate poverty and enhance nutritional outcomes by offering financial incentives that encourage families to invest in child health and nutrition (Pertiwi & Hidayat, 2022). Expanding *Kelas Ibu Balita* (Mother of Toddlers Classes) *Expanding Kelas Ibu Balita* (Mother of Toddlers Classes) could further reinforce behavior change by fostering peer support through regular, structured interactions. These classes provide a platform for mothers to exchange knowledge and experiences, thereby strengthening nutritional awareness and practices at the community level (Sartika et al., 2021).

At the policy level, integrating these targeted strategies into the Healthy Indonesia Program with a Family Approach (*Program Indonesia Sehat dengan Pendekatan Keluarga*, PIS-PK), while concurrently leveraging the e-PPGBM nutrition surveillance dashboard for real-time data monitoring, would facilitate precise and efficient resource allocation, particularly for high-risk populations such as children from low-income households with recent illness histories. By integrating real-time data into nutritional interventions, PIS-PK can more

effectively monitor progress and direct resources to areas of greatest need (Wulandari et al., 2023). While the UNICEF framework offers a robust conceptual foundation for understanding the multifaceted causes of malnutrition, Bronfenbrenner's Ecological Model of Child Development (2021) provides a broader lens. Within this model, maternal education and economic status operate in the mesosystem, shaping child outcomes through both resource availability and the strength of social support networks.

These findings suggest that enhancing maternal nutrition knowledge should be complemented by the strengthening of community-based support structures, such as women's groups, local cooperatives, and family engagement programs. Reinforcing community engagement through these mechanisms can foster environments of mutual support and create opportunities for shared learning and resource exchange (Sutanto et al., 2022). By identifying maternal nutritional knowledge as a modifiable and central determinant of malnutrition, this study aligns directly with several Sustainable Development Goals, specifically SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-Being), and SDG 4 (Quality Education). Addressing this single factor has the potential to generate cross-cutting benefits across economic, health, and educational domains, underscoring the interconnected nature of development priorities. Ultimately, the results affirm that combating rural malnutrition extends beyond food provision, it requires a coordinated, multisectoral approach that empowers caregivers with knowledge, strengthens household economic resilience, ensures access to healthcare services, and addresses cultural practices that may impede optimal child nutrition (Bhutta et al., 2023).

CONCLUSIONS

This study confirms that toddler malnutrition in rural Deli Serdang is driven by a constellation of interconnected factors, poor maternal nutritional knowledge, low household income, recent infectious disease, and insufficient food intake. Among these, inadequate diet and limited maternal knowledge are the most readily modifiable. As one of the first matched case–control studies in rural North Sumatra to apply WHO standards alongside locally sourced data, it underscores the urgent need for integrated interventions that combine nutrition education, poverty alleviation, and infection prevention. Recommended actions include incorporating structured nutrition counseling into *Posyandu* services, expanding conditional cash transfer programs, and strengthening rural health infrastructure. Sustained, multisectoral collaboration is essential to disrupt the cycle of malnutrition and advance child health outcomes.

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