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Determinants Of Malnutrition In Infants In Sulawesi Tengah Province, Indonesia: Central Statistics Agency Of Sulawesi Tengah Province 2025

Clara Anastasya Surentu
Universitas Tadulako, Indonesia
Sumarni
Universitas Tadulako, Indonesia
Abner Gabriel Sugandhi
Universitas Tadulako, Indonesia

Corresponding Author: surentu.clara@gmail.com

Abstract

Indonesia has made significant progress in reducing infant malnutrition at the national level. However, regional inequalities persist, and provinces such as Sulawesi Tengah continue to experience high prevalence and limited progress toward achieving the World Health Organization (WHO) targets. This study aimed to analyze the prevalence of infant malnutrition and its associated factors in Sulawesi Tengah Province using secondary data analysis. Secondary data on infant malnutrition risk factors from 2024 were obtained from publications issued by the Statistics Tengah Agency (BPS) of Sulawesi Tengah Province in 2025. Data from all 13 districts and municipalities in Sulawesi Tengah were analyzed. The variables included live births, low birth weight (LBW), infant malnutrition, Social Security Administering Agency (BPJS) Health Insurance coverage, the number of poor people, and the number of health facilities. Descriptive analysis and multiple linear regression were used to achieve the research objectives. The prevalence of LBW averaged 5.40%, ranging from 2.18% in Banggai Regency to 10.85% in Banggai Laut Regency, indicating substantial regional disparities in maternal and infant health outcomes. The prevalence of infant malnutrition also varied markedly across districts and municipalities, with the highest prevalence observed in Donggala Regency (64.41%) and the lowest in Banggai Laut Regency (5.62%), while the provincial average was 28.12%. Multiple regression analysis revealed that the number of live births (β = 0.582, p = 0.007), LBW (β = 0.535, p = 0.011), and the number of poor people (β = 0.405, p = 0.035) were positively and significantly associated with infant malnutrition.

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In contrast, BPJS Health Insurance coverage (β = −0.320, p = 0.071) and the number of health facilities (β = −0.777, p = 0.002) were negatively associated with infant malnutrition prevalence. In conclusion, infant malnutrition in Sulawesi Tengah exhibited substantial spatial disparities and was significantly associated with low birth weight, poverty, health insurance coverage, and healthcare availability. These findings highlight the importance of strengthening maternal and child health services, expanding BPJS coverage, improving healthcare accessibility, and prioritizing interventions in high-risk districts to reduce the burden of infant malnutrition and promote more equitable nutritional outcomes across the province.

Keywords: Prevalence, Malnutrition, Births, Low Birth Weight, Health Insurance, Health Facilities.

INTRODUCTION

Undernutrition in infants has become a significant public health concern, particularly in developing countries (Sorgho et al., 2017; Nesa et al., 2026). This condition is not merely a consequence of insufficient food intake but is also influenced by environmental, socioeconomic, and health service factors (Musa et al., 2026; Nasaru et al., 2025). If not addressed promptly, especially during the first 24 months of life, undernutrition can result in impaired physical growth, suboptimal cognitive development, increased susceptibility to infections, and long-term adverse consequences for productivity and public health (Samia et al., 2025).

Undernutrition is the most prevalent form of malnutrition in low- and middle-income countries and includes stunting, wasting, underweight, and deficiencies of essential micronutrients (Bain et al., 2013; Owolade et al., 2022; Menalu et al., 2021). Children under five years of age are particularly vulnerable because of their rapid growth and developmental requirements (De Sanctis et al., 2021; Tadele et al., 2022; Obasohan et al., 2020). These conditions increase susceptibility to infectious diseases, diet-related noncommunicable diseases, premature mortality, and poor physical and cognitive outcomes, thereby undermining economic productivity and increasing healthcare expenditures (Owolade et al., 2022; Black et al., 2013; Fan et al., 2022).

The prevalence of undernutrition among children remains high globally, affecting approximately 28.5% of children worldwide and 31.2% in developing countries (WHO, 2017). In Asia, the prevalence reaches 30.6%, while Southeast Asia records a prevalence of 29.4% (WHO,

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2017). This regional pattern reflects the disproportionate burden of undernutrition experienced by South and Southeast Asian countries (MHRI, 2018; Pitoyo et al., 2022). According to UNICEF, nearly 7.8 million Indonesian children experience undernutrition, placing Indonesia among the five countries with the largest burden of child undernutrition worldwide (WHO, 2017). Nationally, the Basic Health Research (Riskesdas) reported that the prevalence of undernutrition among Indonesian children remained unchanged at 17.8% between 2016 and 2017 but declined to 13.8% in 2018 (MHRI, 2018).

Although Indonesia has achieved notable progress in reducing child undernutrition, regional inequalities persist. Provinces such as Sulawesi Tengah continue to report relatively high prevalence and limited progress toward achieving the World Health Organization (WHO) targets (Pitoyo et al., 2022). Stunting, wasting, and underweight are often associated with inadequate nutrition and recurrent infections occurring during critical periods of growth and development (Muliani et al., 2023; Thahir et al., 2023; Ayuningtyas et al., 2022).

Several studies conducted in Sulawesi have identified important determinants of infant malnutrition, including lack of exclusive breastfeeding (EBF), low birth weight (LBW), poor maternal nutritional status, and poverty (Muliani et al., 2023; Saimin et al., 2019). A population-based cohort study in Sulawesi reported that the prevalence of stunting in early infancy reached 18.4%, with prematurity, small-for-gestational-age status, and maternal undernutrition emerging as important correlates of impaired growth (Thahir et al., 2023). Exclusive breastfeeding has also been shown to exert a significant protective effect against adverse nutritional outcomes (Muliani et al., 2023).

Socioeconomic factors further complicate the issue. Maternal education, household income, and health service utilization have been consistently associated with infant nutritional outcomes, with lower maternal education and household poverty contributing to poorer nutritional status (Harahap et al., 2022; Nurbiah et al., 2019; Atamou et al., 2023; Anastasia et al., 2023). Complementary feeding practices and household sanitation have also been identified as important risk factors (Susilowati et al., 2023; Zebadia et al., 2021). In Sulawesi Tengah, geographical diversity, cultural practices such as local food taboos, and limitations in resources may further hinder effective prevention and intervention efforts (Nurbiah et al., 2019).

Despite growing evidence regarding the determinants of child malnutrition in Indonesia, most previous studies have relied on individual- or household-level data. Evidence describing district-level variations and identifying geographical hotspots of infant malnutrition remains

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limited, particularly in Sulawesi Tengah Province. Secondary provincial statistics provide an opportunity to examine spatial disparities across all districts and municipalities, identify areas with the greatest burden, and explore contextual factors associated with infant malnutrition. Such evidence is essential for supporting targeted interventions and improving the allocation of limited nutrition resources.

To our knowledge, no previous study has simultaneously examined the spatial distribution of infant malnutrition and its association with live births, low birth weight, poverty, BPJS Health Insurance coverage, and healthcare facilities using district-level secondary data covering all districts and municipalities in Sulawesi Tengah Province. Therefore, this study aimed to: (i) describe the prevalence and spatial distribution of infant malnutrition across districts and municipalities in Sulawesi Tengah Province; and (ii) examine the associations between live births, low birth weight, the number of poor people, BPJS Health Insurance coverage, healthcare facilities, and infant malnutrition using secondary data analysis. The findings are expected to assist policymakers in identifying high-risk districts and designing more targeted and equitable nutrition intervention strategies.

MATERIALS AND METHODS

Study design and setting

This study employed an ecological study design using district-level secondary data to examine factors associated with infant malnutrition in Sulawesi Tengah Province, Indonesia. Sulawesi Tengah is located in the central part of Sulawesi Island and consists of 12 regencies and one municipality, covering coastal, mountainous, and island areas with diverse socioeconomic and geographic characteristics. The province had an estimated population of 3,121,770 people in 2024. The unit of analysis in this study was the district/municipality (n = 13), rather than individual infants.

Data sources and variables

Secondary data for 2024 were obtained from publications issued by the Central Statistics Agency (BPS) of Sulawesi Tengah Province in 2025. Because complete district-level records were available for all districts and municipalities, no sample size calculation or sampling procedure was required. All 13 districts/municipalities in Sulawesi Tengah Province were included in the analysis.

The variables collected included live births (B), low birth weight (LBW), infant malnutrition

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(M), BPJS Health Insurance coverage (BPJSHI), number of poor people (NPP), and health facilities (HF). Health facilities comprised general hospitals, specialized hospitals, inpatient public health centers, non-inpatient public health centers, primary clinics, and integrated health posts.

Infant malnutrition prevalence (PM) was calculated as the proportion of infants with malnutrition relative to the number of live births in each district/municipality:

$$PM = (M/B) \times 100\%$$

Low birth weight (LBW) referred to infants born weighing less than 2,500 g, consistent with the World Health Organization definition. The number of poor people (NPP) was based on the official poverty classification established by BPS, which defines poor individuals as those with average monthly per capita expenditure below the district-specific poverty line. BPJS Health Insurance coverage referred to the proportion of the population enrolled in Indonesia's National Health Insurance program administered by the Social Security Administering Agency (BPJS Kesehatan). Health facilities represented the total number of healthcare facilities available within each district/municipality.

Statistical analysis

Descriptive statistics were used to describe the prevalence and distribution of infant malnutrition and related factors across districts and municipalities in Sulawesi Tengah Province. Multiple linear regression analysis was employed to examine the associations between live births (B), low birth weight (LBW), number of poor people (NPP), BPJS Health Insurance coverage (BPJSHI), health facilities (HF), and infant malnutrition prevalence (PM). The regression model was specified as follows:

$$PM = \alpha_0 + \alpha_1 B + \alpha_2 LBW + \alpha_3 NPP + \alpha_4 BPJSSHI + \alpha_5 HF + e$$

Where:
PM = M/B*100%,
α_0 = Intercept,
$\alpha_1 - \alpha_5$ = Parameters to be estimated
e = error term

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A p-value of <0.05 was considered statistically significant.

Gender and urban–rural variables

Gender of infants and urban–rural residency were not included in this study because the district-level secondary data published by BPS did not provide disaggregated information on infant malnutrition by sex or place of residence. Consequently, the present study focused on ecological associations at the district level rather than individual-level determinants. Future studies using household- or individual-level datasets are warranted to examine potential gender differences.

RESULTS

Maternal and Infant Health in Sulawesi Tengah

Data on maternal and child health—specifically, the prevalence of low birth weight (LBW) in newborns—in various districts of Sulawesi Tengah in 2024 are presented in Table 1.

Table 1. Maternal and Infant Health Conditions in Sulawesi Tengah 2024

Regency/Municipality*	Births	Low Birth Weight	Percentage of Low Birth Weight
Banggai Kepulauan	1,409	57	4.05
Banggai	3,481	76	2.18
Morowali	2,958	171	5.78
Poso	1,965	151	7.68
Donggala	4,914	416	8.47
Tolitoli	3,398	104	3.06
Buol	3,070	207	6.74
Parigi Moutong	6,610	328	4.96
Tojo Una-Una	1,714	94	5.48
Sigi	2,836	137	4.83
Banggai Laut	1,014	110	10.85
Morowali Utara	1,769	83	4.69
Palu*	6,929	339	4.89

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Sulawesi Tengah Province	42,067	2,273	5.40

Table 1 shows the number of live births, LBW cases, and the prevalence of LBW infants. The provincial average prevalence of LBW was 5.40%, ranging from 2.18% in Banggai Regency to 10.85% in Banggai Laut Regency, indicating substantial disparities in maternal and infant health outcomes across districts.

Number of poor people in Sulawesi Tengah

The population and number of poor people in various regencies and cities in Sulawesi Tengah for 2024 are shown in Table 2.

Table 2. Number of poor people in Sulawesi Tengah, 2024.

Regency/Municipality*	Number of People	Number of Poor People	Percentage of Poor People
Banggai Kepulauan	124,580	14,860	11.93
Banggai	377,600	26,210	6.94
Morowali	173,310	14,990	8.65
Poso	254,060	39,630	15.60
Donggala	311,000	47,680	15.33
Tolitoli	233,900	30,390	12.99
Buol	152,360	23,050	15.13
Parigi Moutong	459,780	74,570	16.22
Tojo Una-Una	170,820	26,120	15.29
Sigi	269,960	29,800	11.04
Banggai Laut	74,020	11,160	15.08
Morowali Utara	127,870	16,740	13.09
Palu*	392,510	24,570	6.26
Sulawesi Tengah Province	3,121,770	379,770	12.17

Table 2 shows that the number of poor people in Sulawesi Tengah in 2024 was 379,770, accounting for 12.17% of the total population of 3,121,770. According to the Central Statistics Agency (BPS), poor people are defined as individuals whose average monthly per capita

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expenditure falls below the poverty line, representing the minimum expenditure required to meet basic food and non-food needs. The lowest poverty rate was recorded in Palu City (6.26%), whereas the highest was observed in Parigi Moutong Regency (16.22%). These findings indicate substantial spatial disparities in economic vulnerability across districts and municipalities in Sulawesi Tengah.

Palu City recorded the lowest percentage at 6.26%, while Parigi Moutong recorded the highest at 16.22%. Several other regencies—Poso, Donggala, Buol, Tojo Una-Una, Banggai Laut, and North Morowali—were above the provincial average. This finding confirms the significant spatial disparity in poverty between regions within the province.

Healthcare Services in Sulawesi Tengah

The percentage of BPJS (Social Security Administration) and healthcare facilities for each district/city in Sulawesi Tengah is shown in Table 3.

Table 3. Healthcare Services in Sulawesi Tengah 2024.

Regency/ Municipality*	BPJSHI (%)	Number of health facilities (Units)
Banggai Kepulauan	74.75	195
Banggai	71.91	421
Morowali	82.08	184
Poso	77.97	324
Donggala	63.04	470
Tolitoli	74.91	296
Buol	82.82	175
Parigi Moutong	65.95	499
Tojo Una-Una	89.01	231
Sigi	64.44	351
Banggai Laut	53.45	99
Morowali Utara	83.54	214
Palu*	83.09	298
Sulawesi Tengah Province	74.38	3,757

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Table 3 illustrates significant variations in BPJS coverage and healthcare facility availability across regencies/cities in Sulawesi Tengah in 2024. Tojo Una-Una had the highest BPJS coverage (89.01% with 231 facilities), whereas Banggai Laut had the lowest (53.45% with 99 facilities). Palu demonstrated high coverage (83.09%), consistent with its role as a service center with 298 facilities. In terms of infrastructure, Parigi Moutong had the largest number of facilities (499 units), followed by Donggala (470) and Banggai (421), totaling 3,757 facilities, with an average BPJS coverage of 74.38%. The incomplete BPJS coverage across districts may reflect geographic barriers in remote and archipelagic areas, the predominance of informal workers who must independently finance their insurance contributions, and differences in local government capacity to subsidize vulnerable populations. Access to BPJS is generally obtained through government-funded membership for poor households, employer-based schemes for formal workers, and voluntary enrollment among informal-sector participants. These findings highlight substantial inequalities in both insurance coverage and access to healthcare services across districts in Sulawesi Tengah.

Prevalence of Malnutrition in Infants

Data on the number of live births and the prevalence of infant malnutrition in various regions of Sulawesi Tengah for 2024 are shown in Table 4.

Table 4. Number of live births and infant malnutrition in Sulawesi Tengah, 2024.

Regency/Municipality*	Births	Malnutrition	Prevalence of Malnutrition in Infants
Banggai Kepulauan	1,409	201	14.27
Banggai	3,481	483	13.88
Morowali	2,958	833	28.16
Poso	1,965	166	8.45
Donggala	4,914	3,165	64.41
Tolitoli	3,398	878	25.84
Buol	3,070	451	14.69
Parigi Moutong	6,610	2,234	33.80
Tojo Una-Una	1,714	828	48.31

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Sigi	2,836	1,300	45.84
Banggai Laut	1,014	57	5.62
Morowali Utara	1,769	384	21.71
Palu*	6,929	848	12.24
Sulawesi Tengah Province	42,067	11,828	28.12

Table 4 shows wide variations in the prevalence of undernutrition among infants across districts and cities—the highest in Donggala (64.41%) and the lowest in Banggai Laut (5.62%), with a provincial average of 28.12%. This pattern highlights significant spatial disparities and underscores the need to refine intervention targeting in high-risk areas.

Factors Influencing the Prevalence of Malnutrition in Infants in Sulawesi Tengah

Estimates of factors influencing the prevalence of malnutrition in infants in Sulawesi Tengah are shown in Table 5.

Table 5. Estimated Factors Influencing the Prevalence of Malnutrition in Infants in Sulawesi Tengah

Variables	Coefficient	Standard error	P value
Intercept	6.354		
Number of live births	0.582***	0.153	0.007
Low birth weight	0.535**	0.156	0.011
Number of poor people	0.405**	0.156	0.035
BPJS	-0.320*	0.151	0.071
Number of health facilities	-0.777***	0.154	0.002
F	11.383		0.003

Note: * significant at α 1%, ** significant at α 5%, * significant at α 10%**

The regression model was statistically significant (F = 11.383, p = 0.003), indicating that the explanatory variables jointly accounted for variations in the prevalence of infant malnutrition across districts and municipalities in Sulawesi Tengah. The number of live births, low birth weight cases, and the number of poor people were positively and significantly associated with infant

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malnutrition prevalence. In contrast, BPJS Health Insurance coverage and the number of health facilities were negatively associated with infant malnutrition prevalence, suggesting that broader health insurance coverage and better availability of healthcare services may contribute to reducing the burden of infant malnutrition.

DISCUSSION

Banggai Laut Regency recorded the highest prevalence of low birth weight (LBW) (10.85%) despite having the lowest number of live births (1,014). This pattern may reflect underlying disparities in maternal health conditions and access to healthcare services in geographically isolated areas. Limited access to maternal and child health services, inadequate maternal nutritional intake, and unfavorable socioeconomic conditions may contribute to the higher prevalence of LBW. As an archipelagic district, Banggai Laut may also face challenges related to transportation, referral systems, and the availability of specialized maternal healthcare, making the delivery of nutrition interventions more difficult. Similarly, Donggala (8.47%) and Poso (7.68%) also exhibited relatively high LBW prevalence, suggesting that these areas may experience comparable constraints. Previous studies have consistently identified inadequate antenatal care utilization, poor maternal nutritional status, maternal anemia, socioeconomic disadvantage, and limited access to health services as major determinants of LBW in Indonesia. Sari et al. (2025) reported that household food insecurity, maternal characteristics, and socioeconomic factors were significantly associated with LBW incidence in Indonesia. Likewise, Arabzadeh et al. (2024), in an umbrella review, concluded that maternal factors, including poor nutritional status, inadequate prenatal care, pregnancy complications, and low socioeconomic status, substantially increase the risk of delivering LBW infants. In contrast, Banggai Regency (2.18%) and Tolitoli (3.06%) showed relatively lower LBW prevalence, which may be related to more effective maternal health programs, broader antenatal care coverage, and differences in demographic and environmental conditions. Overall, these findings suggest that LBW in Sulawesi Tengah is multifactorial in nature, encompassing clinical, nutritional, socioeconomic, educational, and geographic determinants.

The observed pattern is consistent with the concept of geographic poverty traps proposed by Jalan and Ravallion (2002), which suggests that households residing in areas with limited geographic capital and poor connectivity may remain trapped in persistent poverty because they are unable to fully benefit from economic growth and market opportunities. Barrett and Carter

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(2013) further argued that spatial disadvantages can reinforce chronic poverty through restricted access to productive assets and services. In the Indonesian context, Arif et al. (2025) demonstrated that remote, mountainous, and island regions tend to exhibit higher poverty rates due to structural constraints. These findings help explain the spatial poverty patterns observed in Sulawesi Tengah. Districts with relatively high poverty rates, such as Parigi Moutong (16.22%), Poso (15.60%), and Donggala (15.33%), are characterized by greater dependence on primary-sector livelihoods, weaker connectivity to growth centers, and more limited access to infrastructure and public services. In contrast, Palu City, which recorded the lowest poverty rate (6.26%), benefits from better transportation networks, more diversified employment opportunities, and greater concentration of public services. This suggests that poverty in Sulawesi Tengah is shaped not only by household characteristics but also by spatial factors, including market accessibility, infrastructure availability, and the strength of local economic networks.

Palu City's relatively lower poverty rate may be attributed to greater availability of non-agricultural employment opportunities, better public services, and more developed infrastructure networks that reduce transaction costs and expand access to economic and social services. Similar findings have been reported in previous studies of urban Indonesia. Suryahadi and Marlina (2019), the World Bank (2020), and Amin et al. (2025) found that livelihood diversification, human capital, and access to urban economic opportunities played important roles in reducing poverty among vulnerable populations. Furthermore, Suryahadi and Marlina (2019) and Alfin and Boedirochminarni (2025) showed that urban areas in Indonesia generally experience lower poverty rates due to higher educational attainment, broader labor market opportunities, and better access to public services compared with rural areas. These findings support the empirical observation that urban centers such as Palu tend to exhibit lower poverty levels than predominantly rural districts.

Conversely, districts with higher poverty rates are generally characterized by agrarian-based economies, limited economic diversification, and peripheral geographic locations. Previous studies have demonstrated that rural and remote communities in Indonesia are more vulnerable to persistent poverty because of restricted access to education, healthcare, financial services, and labor markets. Ayuningtyas et al. (2022) reported substantial geographic and socioeconomic disparities across Indonesian districts, highlighting that limited access to public services contributes to poorer development outcomes. Similarly, Brata et al. (2021) found that socioeconomic shocks, including the COVID-19 pandemic, disproportionately affected

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disadvantaged regions and widened existing inequalities. Arif et al. (2025) further emphasized that remoteness and weak connectivity can reinforce spatial poverty traps by limiting households' ability to benefit from economic growth. These findings are consistent with the situation in Sulawesi Tengah, where non-urban and island districts appear to face greater structural barriers to poverty reduction.

Mechanistically, adequate infrastructure—such as roads, electricity, water/sanitation, and digital connectivity—is associated with poverty reduction through reduced logistics costs, increased productivity, and expanded market access. Multi-regional studies and Indonesian evidence indicate that well-targeted infrastructure investments significantly reduce poverty, particularly when integrated with policies that enhance access to and quality of services (Straub et al., 2024).

The policy implications of these findings point to the importance of place-based policies tailored to local contexts rather than relying solely on uniform national programs. Recent international literature suggests that geographically targeted interventions, including Special Economic Zones (SEZs), improvements in transportation connectivity, and area-specific development initiatives, can enhance well-being and stimulate local economic growth, although their effectiveness depends heavily on policy design, governance quality, and integration with surrounding economies. Suedekum (2025) emphasized that place-based policies are most effective when they strengthen local comparative advantages while fostering linkages with regional growth centers. Similarly, Rodríguez-Pose and Wilkie (2017) argued that development strategies designed around local assets and constraints are more successful in reducing territorial inequalities than one-size-fits-all approaches. In the Indonesian context, Straub et al. (2024) demonstrated that investments in infrastructure and effective access to public services significantly contribute to poverty reduction, particularly in lagging regions. Furthermore, Arif et al. (2025) showed that weak connectivity and geographic isolation reinforce spatial poverty traps, limiting the ability of households to benefit from broader economic growth. Therefore, development planning for high-poverty districts in Sulawesi Tengah should prioritize improvements in physical and economic connectivity, strengthen local capabilities, and integrate local value chains with regional growth centers such as Palu and Banggai.

As a methodological refinement, disparity monitoring can be strengthened by incorporating high-resolution poverty mapping (e.g., spatial poverty indices based on nighttime imagery, built-up indices, and Points of Interest, or POIs) to identify vulnerable pockets at a micro

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level. This approach is relevant for targeting infrastructure and public service interventions in the most disadvantaged villages/sub-districts (Putri et al., 2022).

Conceptually, access to healthcare encompasses not only coverage and availability, but also the dimensions of accessibility, acceptability, affordability, and accommodation—a framework known as the "5A's of access." This framework is widely used to diagnose access barriers and design interventions, particularly post-pandemic, when telehealth and digital factors also influence service access (Cynthia et al., 2021). In the context of Sulawesi Tengah, this explains disparities in healthcare utilization observed across districts.

At the same time, healthcare utilization behavior is influenced by predisposing, enabling, and need factors, as described by Andersen's Behavioral Model. Cross-country evidence and recent reviews indicate that need factors (morbidity and symptom severity) tend to be the strongest determinants, but enabling factors—including insurance (BPJS), distance, and transportation costs—remain instrumental in shaping utilization disparities, particularly for referral services and hospitals (Alkhawaldeh et al., 2023). This framework helps explain the variation observed in Sulawesi Tengah, where districts with lower BPJS coverage and fewer healthcare facilities may face greater barriers to accessing maternal and child health services. Previous studies in Indonesia have shown that health insurance coverage reduces financial barriers to healthcare utilization (Maulana et al., 2022), whereas the density and proximity of healthcare facilities contribute to reducing geographical inequalities in service use (Mulyanto et al., 2020). Therefore, disparities in BPJS enrollment and healthcare infrastructure may contribute to unequal access to health services and ultimately influence health outcomes across districts.

Furthermore, a high number of facilities does not automatically translate to effective access. Geospatial literature emphasizes the importance of spatial access metrics (travel time, land-sea connectivity, transport affordability) in Indonesia's archipelagic/remote regions; two regions with similar numbers of facilities can have significantly different access due to geographic barriers and transportation networks. GIS approaches, and measures of potential spatial access (e.g., gravity/E2SFCA) are recommended for mapping micro-inequality gaps and targeting interventions (Agustina et al., 2019).

In line with the UHC agenda, the relevant evaluation indicator is not just "nominal coverage." Still, adequate coverage—that is, the affordability of quality services patients actually receive according to their clinical needs. GBD's global analysis of adequate coverage shows that increasing access must be accompanied by strengthening the quality/readiness of services to lead

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to better health outcomes. This is crucial for districts with numerous facilities but disproportionate health outcomes (Leosari et al., 2023).

Policy implications for Sulawesi Tengah include: (i) expanding BPJS coverage in underdeveloped areas (e.g., Banggai Laut) accompanied by subsidies for transportation costs or referral routes that reduce travel time; (ii) strengthening primary care (networked community health centers) and health workers in island/rural areas; (iii) investing in connectivity infrastructure (roads/docks) to reduce health logistics costs; and (iv) monitoring household finances (OOP and catastrophic spending) as an indicator of financial protection (Lozano, 2020).

Furthermore, the work context and experiences of health workers suggest that system resilience varies between urban and rural areas, as PPE availability, workload, and referrals impact service continuity. Understanding the service provider perspective helps explain why high BPJS coverage does not always guarantee equal access on the ground (Sutrisni et al., 2023).

Some of the most consistent factors associated with infant/child malnutrition are: (i) Maternal nutritional and health status (including anemia, micro/macronutrient intake) and low birth weight (LBW)—which impacts early growth and the risk of postnatal undernutrition; recent Indonesian evidence links LBW to social determinants and inadequate antenatal care (Sari et al., 2025); (ii) Exclusive breastfeeding (EBF) and IYCF practices: Indonesian studies show EBF is associated with a protective effect against growth retardation; a recent global meta-analysis also supports strengthening EBF through behavioral interventions. (Although much of the evidence uses stunting as the primary outcome, the direction of the association is similar for the risk of undernutrition in early life) (Dib et al., 2024); (iii) Socioeconomic and urban–rural context: Disparities in service access, maternal education, and household poverty mediate food consumption and health service utilization, widening regional differences in nutritional outcomes (Siramaneerat et al., 2024).

Policy implications should be interpreted in light of the factors identified in this study. Because low birth weight and poverty were significantly associated with higher infant malnutrition prevalence, interventions targeting the prenatal period and vulnerable households are likely to yield substantial benefits. In line with the latest global evidence, maternal interventions, including iron–folic acid or multiple micronutrient (MMN) supplementation, balanced energy–protein supplementation during pregnancy, and improvements in the coverage and quality of antenatal care (ANC), are essential to reduce the risk of LBW and improve birth outcomes (Alristina et al., 2025). Given that LBW represents an important pathway leading to

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subsequent malnutrition, strengthening maternal nutrition before and during pregnancy may interrupt this cycle at an early stage. Similarly, infant and young child interventions remain critical. Promotion and support of exclusive breastfeeding during the first six months of life, appropriate infant and young child feeding (IYCF) counseling, and context-specific prevention and management of wasting can improve dietary intake and growth during the most vulnerable period of child development. Evidence syntheses, including Cochrane reviews, have demonstrated that early nutrition interventions in low- and middle-income countries are more effective when integrated with strengthened primary healthcare systems (Hadi et al., 2021). Furthermore, the substantial disparities observed across districts suggest that universal strategies alone may be insufficient. Spatially targeted approaches that prioritize districts and villages with the highest burden of malnutrition, poverty, and LBW may improve program efficiency and equity. Consistent with recent evidence from Indonesia, interventions directed toward geographically disadvantaged populations can accelerate reductions in nutritional inequalities by addressing key risk factors throughout the continuum from pregnancy to early childhood (Siramaneerat et al., 2024). These findings underscore the importance of combining maternal nutrition programs, child nutrition interventions, poverty-sensitive strategies, and improved access to healthcare services to achieve more equitable improvements in infant nutritional outcomes.

Number of live births (+). The positive and significant coefficient (β≈0.582; p=0.007) supports resource dilution theory: as the number of children increases, household resources (nutritious food, caregiving time, healthcare costs) are "shared," increasing the risk of child malnutrition. Recent evidence shows traces of resource dilution on feeding practices and child nutritional outcomes, including the effect of birth order on anthropometric outcomes (Ruggiero et al., 2023). This finding is consistent with the regression results presented in Table 5.

Low birth weight (LBW) was positively and significantly associated with infant malnutrition (β ≈ 0.535; p = 0.011), indicating that infants born with LBW are more likely to experience subsequent nutritional deficits. This finding is consistent with previous evidence demonstrating that LBW increases the risk of undernutrition and stunting among children aged 0–59 months, particularly in Asia and other low- and middle-income countries [54]. Similar findings have also been reported in Indonesia. Saimin et al. (2019) found that children born with LBW in coastal communities had a significantly higher risk of malnutrition compared with those with normal birth weight (Saimin et al., 2019). Furthermore, a population-based cohort study conducted in

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Sulawesi by Thahir et al. (2023) identified adverse birth conditions, including prematurity and small-for-gestational-age status, as important determinants of impaired early growth and stunting (Thahir et al., 2023). These findings suggest that inadequate fetal growth may initiate a trajectory of nutritional vulnerability that persists throughout early childhood. Therefore, strengthening maternal and perinatal interventions—including high-quality antenatal care, iron–folic acid or multiple micronutrient supplementation, and strategies to prevent prematurity—may help interrupt this pathway early in life (Vats et al., 2024). Such interventions are particularly relevant in districts with high LBW prevalence, such as Donggala and Poso.

The positive association between the number of poor people and infant malnutrition ($\beta \approx 0.405$; $p = 0.035$) suggests that socioeconomic disadvantage remains an important determinant of poor nutritional outcomes. Poverty may increase the risk of malnutrition through multiple pathways, including reduced dietary diversity and food quality, inadequate sanitation and living conditions, and limited utilization of healthcare services (Ayuningtyas et al., 2022). Similar findings have been reported in previous studies in Indonesia. Ayuningtyas et al. (2022) documented substantial geographic and socioeconomic disparities in child undernutrition across Indonesian districts, demonstrating that poorer populations bear a disproportionate nutritional burden (Ayuningtyas et al., 2022). Harahap et al. (2022) further reported that household economic conditions significantly influenced the nutritional status of infants aged 0–6 months Harahap et al., 2022). Likewise, studies by Atamou et al. (2023) and Anastasia et al. (2023) identified low socioeconomic status as a key determinant of stunting among Indonesian children under five years of age Atamou et al., 2023); Anastasia et al., 2023). Collectively, these findings indicate that reducing infant malnutrition requires not only nutrition-specific interventions but also broader poverty alleviation strategies that improve household food security, living conditions, and access to health services.

BPJS Coverage (−). A negative coefficient ($\beta \approx -0.320$; $p = 0.071$; marginal significance at 10%) indicates that BPJS coverage may reduce malnutrition risk. Evidence from 2018 to 2025 shows that JKN/BPJS has reduced out-of-pocket costs and expanded access, although regional disparities persist (Maulana et al., 2022).

Number of health facilities (−). The strong negative coefficient ($\beta \approx -0.777$; $p = 0.002$) is consistent with evidence that service density and proximity improve utilization and equity of access, including in disadvantaged areas. However, many studies emphasize that the quantity of facilities needs to be followed by effective spatial access (travel time, land-sea connectivity) and

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service quality (effective coverage) to lead to improved child nutrition (Mulyanto et al., 2020). This is consistent with the negative coefficient observed in the regression model (Table 5).

Policy implications: (i) Upstream interventions: maternal-perinatal packages to reduce low birth weight (quality antenatal care, iron/MMN supplementation, prematurity prevention) (Arabzadeh et al., 2024); (ii) Financial protection: Accelerate the expansion of BPJS (Social Security Agency) in vulnerable areas, plus strategies to reduce non-medical costs (transportation/accommodation) to increase utilization of nutrition and maternal and child health services (Maulana et al., 2022); (iii) Access and quality of services: Increase facility density in peripheral and island areas, optimize spatial access (routes/docks/transportation), and focus on effective coverage (not just the number of visits) (Mulyanto et al., 2020); and (iv) Poverty alleviation: Integrate nutrition programs with social assistance and household food security interventions in high-poverty districts (Ayuningtyas et al., 2022).

CONCLUSION

The average prevalence of LBW in Sulawesi Tengah Province was 5.40%. Banggai Laut Regency recorded the highest prevalence of LBW (10.85%), followed by Donggala Regency (8.47%) and Poso Regency (7.68%). The average prevalence of infant malnutrition in the province was 28.12%, with the highest in Donggala Regency (64.41%) and the lowest in Banggai Laut (5.62%). This pattern highlights significant spatial disparities and underscores the need for targeted interventions in high-risk areas. The regression analysis yielded $F = 11.383$, $p = 0.003$, indicating overall significance ($\alpha \leq 1\%$). This implies that all variables included in the model jointly influence infant malnutrition in Sulawesi Tengah Province. The number of live births ($\beta \approx 0.582$; $p=0.007$), low birth weight ($\beta \approx 0.535$; $p=0.011$), and the number of poor people ($\beta \approx 0.405$; $p=0.035$) had positive and significant effects on infant malnutrition in Sulawesi Tengah Province. Meanwhile, BPJS coverage ($\beta \approx -0.320$; $p=0.071$) and the number of health facilities ($\beta \approx -0.777$; $p=0.002$) had negative, significant effects.

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