



The relationship between access to safe drinking water and the village development index and stunting prevalence: A secondary data analysis

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ABSTRACT

Background: Stunting is a chronic nutritional problem that reflects a failure to achieve optimal growth due to prolonged undernutrition, particularly during the first 1000 days of life. One of the key environmental determinants influencing stunting is access to safe drinking water and the overall condition of rural development. This study aimed to analyze the relationship between access to safe drinking water and the village development index/*indeks desa membangun* (VDI/IDM) on the prevalence of stunting in Indonesia in 2024. **Methods:** This study employed a secondary data analysis design with a quantitative approach. Data were obtained from the 2024 Indonesia nutrition status survey/*survei status gizi Indonesia* (SSGI), the VDI from the Ministry of Villages, and the Central Bureau of Statistics/*Badan Pusat Statistik* (BPS). Data were analyzed using Kendall's Tau-b correlation and multiple linear regression tests. **Findings:** Analysis of 37 provinces revealed a negative relationship between access to safe drinking water and stunting prevalence ($r = -0.277$; $p\text{-value} = 0.018$), and a stronger relationship between the VDI and stunting ($r = -0.418$; $p\text{-value} < 0.001$). Multivariate analysis showed that only the VDI had a significant effect on stunting ($\beta = -0.591$; $p\text{-value} = 0.001$). These findings support the Social Determinants of Health theory, emphasizing that the reduction of stunting is more strongly influenced by comprehensive village development than by a single environmental factor such as water access. **Conclusion:** This highlights the importance of a multidimensional, socially driven development approach to accelerate national stunting reduction efforts. **Novelty/Originality of this article:** This study introduces a novel approach by linking the VDI with stunting prevalence, demonstrating the role of rural development as a social determinant—an aspect that has been rarely explored in previous research. The novelty lies in presenting rural development as an integral dimension in addressing nutritional disparities across regions.

KEYWORDS: access to safe drinking water; stunting; village development index.

1. Introduction

The global prevalence of stunting has shown a declining trend; however, it remains a major public health concern. According to recent estimates, approximately 22.3% of children under five years of age were stunted worldwide in 2022, equivalent to around 148.1 million children (World Health Organization, 2023). Stunting not only reflects chronic nutritional deficiencies but also serves as an indicator of inequality in human development and child growth, as stunted children are at risk of failing to achieve their full physical and cognitive potential (World Health Organization, 2023). In response to these ongoing global

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challenges, the scientific discourse on stunting has expanded rapidly over the past decade, necessitating a comprehensive mapping and evaluation of existing research focuses. Such mapping is essential to identify potential knowledge gaps that have not yet been addressed by previous studies and to ensure that planned interventions are supported by a robust and up-to-date scientific evidence base (Deda et al., 2024). A structured understanding of the evolution of stunting research is crucial, particularly in addressing stunting, which remains a major child health concern in many low- and middle-income countries, including Indonesia. In Indonesia, stunting continues to be one of the primary indicators of nutritional problems despite notable progress over the past decade. The prevalence has decreased from 37.6% in 2013 to 19.8% in 2024. According to the Indonesian Ministry of Health (2024), the national prevalence of stunting currently stands at 21.5%, which has not yet achieved the target of 14% as set in the National Medium-Term Development Plan/*Rencana Pembangunan Jangka Menengah Nasional (RPJMN)* 2024 (Indonesian Nutritional Status Survey, 2024). Based on Figure 1, maroon indicates a very high stunting prevalence (>40%), red indicates a high prevalence (30–39.9%), yellow indicates a medium prevalence (20–29.9%), and green indicates a low prevalence (0–19.9%).

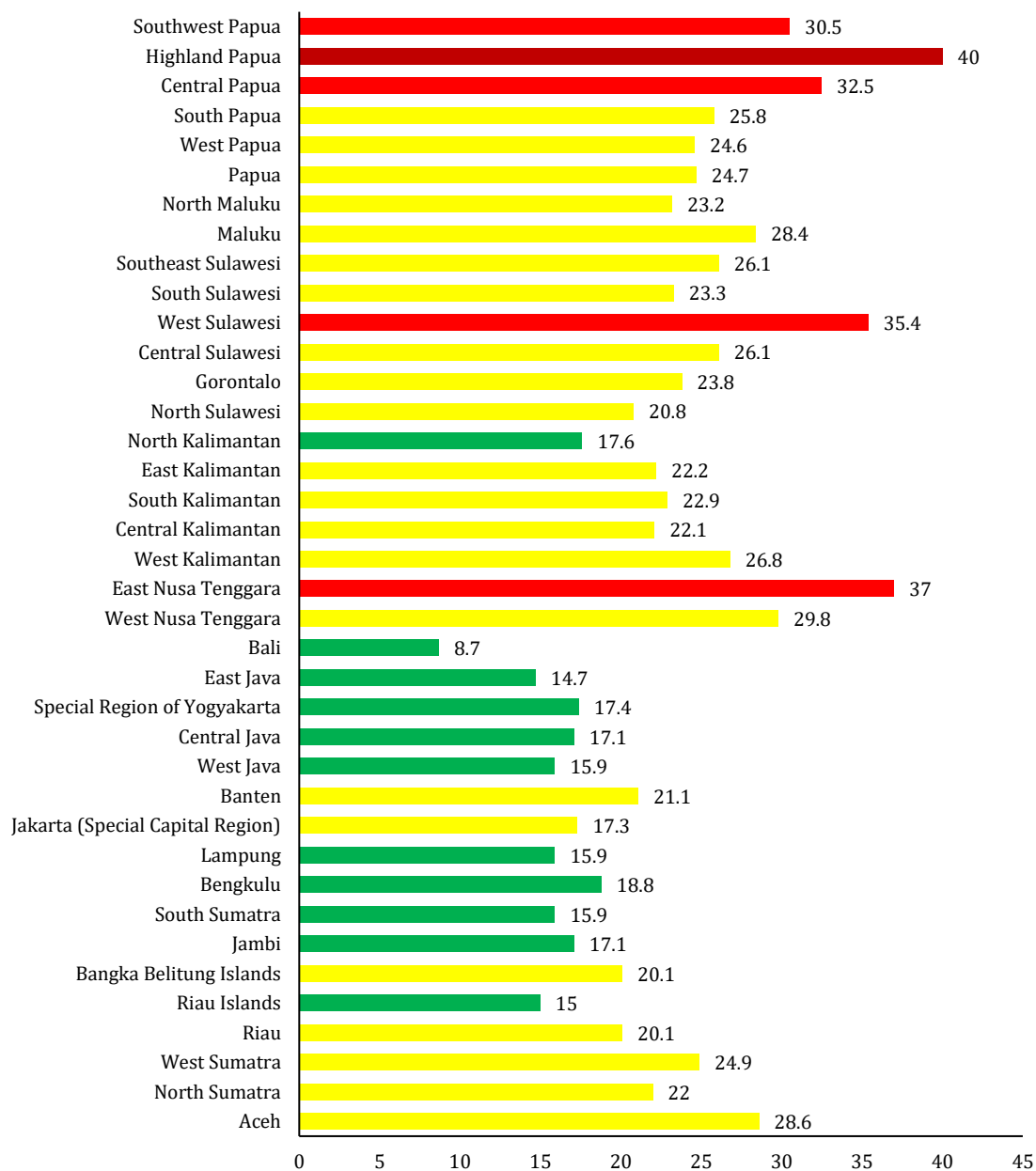


Fig. 1. Map of stunting prevalence by province in Indonesia
(Stunting Reduction Acceleration Team, 2024)

Stunting is a severe chronic nutritional problem in Indonesia, driven by multifactorial and intergenerational determinants. Integrated and cross-sectoral efforts to address stunting must be prioritized, particularly through a strong focus on the National Movement for the first 1,000 days of life (Aryastami, 2017). Regional disparities remain substantial, with most stunting cases concentrated in only a few provinces. This condition underscores the need for more targeted, evidence-based, and cross-sectoral interventions to ensure that national and global targets for stunting reduction can be achieved sustainably (Ministry of Health of the Republic of Indonesia, 2025). Geographical disparities persist, with stunting prevalence tending to be higher in rural areas than in urban settings. This gap is influenced by a complex interplay of factors, including socio-demographic characteristics, economic inequality, environmental conditions, maternal education, and, most critically, accessibility to healthcare services (Astari et al., 2023). Stunting in Indonesia is a multidimensional issue rooted in various factors, including socioeconomic inequality, limited access to safe water, inadequate sanitation and environmental conditions, and unequal development between rural and urban areas (Lestari, 2023).

Access to safe drinking water is one of the indicators of sustainable development goal (SDG) 6 on clean water and sanitation (Johnston, 2016). Data from Central Bureau of Statistics/*Badan Pusat Statistik* (BPS) in 2024 indicate that household access to safe drinking water increased to 92.64%, with DKI Jakarta recording the highest rate at 99.96%, while Papua Pegunungan reported the lowest at 30.64%. This disparity reflects infrastructural inequality and underscores the urgent need for equitable policies to ensure access to safe drinking water across all regions of Indonesia (Central Bureau of Statistics, 2024). Limited access to clean or safe drinking water increases the risk of infectious diseases such as diarrhea and helminthiasis, which impair nutrient absorption and hinder child growth (Putri et al., 2022). Previous studies have shown that improved access to safe and reliable drinking water is associated with lower stunting prevalence (Paramasatya & Wulandari, 2023). Households with adequate access to clean water and sanitation have a lower risk of stunting compared to those with inadequate access (Olo et al., 2021).

Furthermore, inequality in development can be reflected through the Village Development Index/*indeks desa membangun* (IDM), which provides a multidimensional framework describing village independence based on social, economic, and ecological dimensions (Ministry of Villages, 2023). The development gap between rural and urban areas in Indonesia remains evident, as reflected by the higher rural poverty rate of 12.22% compared to 7.29% in urban areas, along with disparities in access to basic services such as healthcare (Ministry of Villages, 2023). Rural areas continue to be associated with limitations and isolation, requiring serious attention to prevent the widening of the rural–urban divide. The Village Fund Policy has contributed to reducing rural–urban inequality by approximately 0.0335–0.0462 however, its overall impact on national development equity remains limited (Mudzakir, 2025). Studies have indicated significant disparities between rural and urban areas in health outcomes, health behaviors, clinical services, and social as well as environmental health determinants, which indirectly contribute to variations in stunting prevalence (Weeks et al., 2023). Villages with higher IDM scores are expected to have better infrastructure and basic services including sanitation and clean water which contribute to the reduction of stunting.

While access to safe drinking water and village development have been extensively studied separately, research simultaneously examining their combined influence on stunting prevalence remains limited. This gap constrains evidence-based policymaking for development and public health planning. Therefore, this study utilizes secondary data from the 2024 Indonesian nutrition status survey/*survei status gizi Indonesia* (SSGI), the village development index/*indeks desa membangun* (IDM), and Central Bureau of Statistics/*Badan Pusat Statistik* (BPS) to analyze the relationship between access to safe drinking water, village development status, and stunting prevalence across provinces in Indonesia. This research contributes new insights by integrating environmental health and rural development perspectives to explain stunting disparities. The study hypothesizes that, (H1) higher household access to safe drinking water is associated with lower stunting

prevalence, and (H2) higher village development index status is associated with lower stunting prevalence. This approach is expected to provide updated empirical evidence to support policy formulation toward Indonesia's stunting reduction targets.

2. Methods

This study employed a quantitative approach with an ecological study design (Akbar et al., 2024). The analysis was conducted at the provincial level in Indonesia to assess the relationship between access to safe drinking water, village development status (measured by the village development index or *indeks desa membangun*/IDM), and stunting prevalence. This design was chosen because it allows for mapping macro-level relationships between variables using official secondary data that are aggregate and nationally representative.

The study covered 37 provinces in Indonesia, consistent with the coverage of the 2024 Indonesia Nutritional Status Survey (Indonesian Nutritional Status Survey, 2024), Village Development Index (IDM 2024), and Central Bureau of Statistics (Central Bureau of Statistics, 2024) data. The selection of these administrative units was based on the availability, comprehensiveness, and consistency of the secondary data, as well as their relevance to the national stunting reduction targets. Data analysis was conducted in October 2025 in Figure 2.



Fig.2. Research Location

The data used in this study were secondary data obtained from three main sources: the 2024 Indonesia nutritional status survey (Indonesian Nutritional Status Survey, 2024) for provincial-level stunting prevalence (%), the Village Development Index (IDM 2024) for village development status, and central bureau of statistics (Central Bureau of Statistics, 2024) for the percentage of households with access to safe drinking water. The study variables included the prevalence of stunting (percentage of stunted children under five in each province) as the dependent variable, while the percentage of households with access to safe drinking water and the Village Development Index (IDM) score served as independent variables.

Data were analyzed using SPSS software version 25. The analytical stages included bivariate analysis using Kendall's Tau-b correlation to assess the strength and direction of the relationships between stunting prevalence and each independent variable. Multivariate analysis was performed using multiple linear regression to examine the simultaneous effects of access to safe drinking water and village development status on stunting prevalence. The level of significance was set at $\alpha = 0.05$, with a negative relationship indicating that higher access to safe drinking water or a higher IDM score corresponds to

lower stunting prevalence. This study is grounded in the understanding that stunting is a multidimensional phenomenon influenced by social, environmental, and regional development conditions. Epistemologically, a quantitative approach was employed to obtain empirical evidence based on aggregate data that can support national policy formulation for stunting reduction through village development and environmental health interventions.

3. Results and Discussion

3.1 Overview of stunting prevalence in Indonesia

The results of the nutrition status survey/*survei status gizi Indonesia* (SSGI) indicate a consistent decline in the national stunting prevalence over recent years. In 2020, the stunting prevalence was recorded at 27.7%, decreasing to 24.4% in 2021, 21.6% in 2022, and 21.5% in 2023. The year 2024 demonstrated a positive achievement, with the prevalence reaching 19.8%, which is lower than the national target of 20.1% in Figure 3.

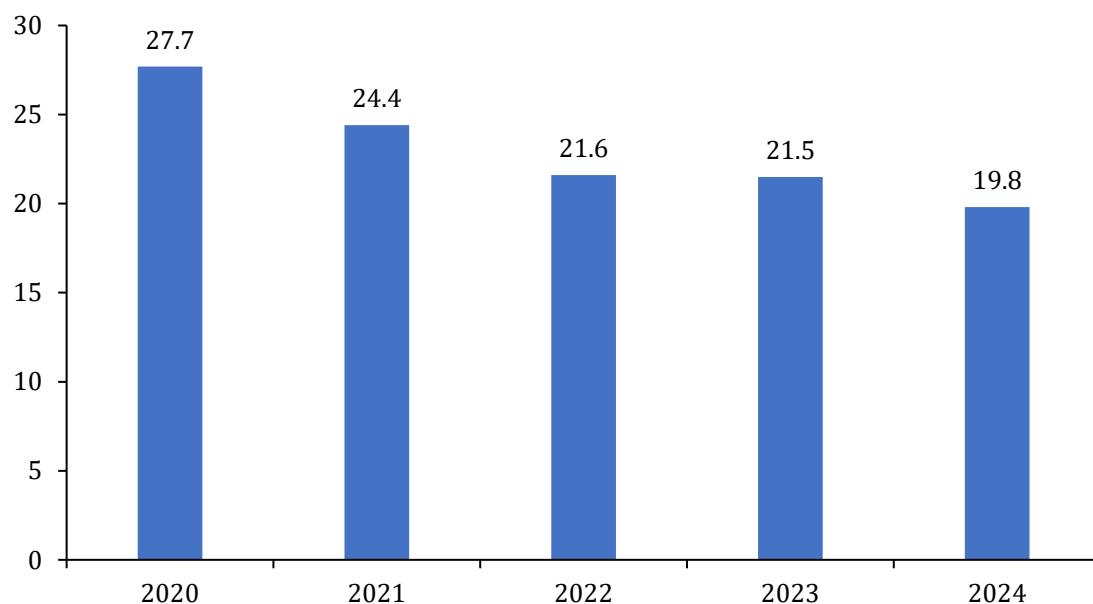


Fig. 3. Distribution of stunting in Indonesia

Although these achievements indicate significant progress, inter-provincial disparities remain substantial. Several provinces such as East Nusa Tenggara, West Sulawesi, and Highlands Papua still report stunting prevalence rates above 30%, whereas provinces like Jakarta Capital Region (DKI Jakarta) and Bali have the lowest prevalence rates, below 15%. This pattern indicates that social, economic, and environmental factors continue to play a critical role in determining the nutritional status of children at the regional level.

3.2 Distribution frequency of access to safe drinking water in Indonesia

The univariate analysis shows that the average access to safe drinking water in Indonesia is relatively high. However, a considerable variation exists among provinces, as indicated by the wide range between the minimum and maximum values, reflecting unequal access across regions. Provinces in eastern Indonesia generally exhibit lower levels of access to safe drinking water compared to those in the western and central parts of the country.

Tabel 1. Distribution Frequency of access to safe drinking water

Access to Safe Drinking Water	F	%
Suitable	32	86,5
Not suitable	5	13,5

3.3 Distribution frequency of the village development index in Indonesia

The univariate analysis shows that the average Village Development Index (IDM) indicates that most regions fall into the developed or independent categories. This finding suggests that overall village development in Indonesia has improved, although disparities persist among provinces. Regions with lower IDM scores tend to have more limited access to safe drinking water, which may hinder efforts to reduce stunting nationally.

Tabel 2. Distribution frequency of village development index

Village Development Index	F	%
Independent	2	5.4
Developed	19	51.4
Developing	10	27.0
Underdeveloped	4	10.8
Highly underdeveloped	2	5.4
Total	37	100

3.4 Relationship between access to safe drinking water and stunting prevalence

The results of the Kendall's Tau-b correlation test indicated a significant negative relationship between the percentage of households with access to safe drinking water and the prevalence of stunting ($r = -0.277$; $p\text{-value} = 0.018$). This finding suggests that the higher the proportion of households with access to safe drinking water, the lower the stunting prevalence in the corresponding province.

Table 3. Kendall's tau-b correlation between access to safe drinking water and stunting prevalence

Variable	Stunting prevalence		
	Coefficient (t)	Sig. (2-tailed)	N
Access to safe drinking water	-0.277	0.018	37

This relationship is consistent with studies indicating that access to safe drinking water and adequate household sanitation facilities are significantly associated with stunting incidence. Three out of five international studies analyzed found that children without access to clean water and proper sanitation were at higher risk of stunting (Nur'aeni, 2023). Untreated or unhygienically stored water can lead to diarrheal diseases and environmental enteric dysfunction (EED), which impair nutrient absorption and inhibit child growth (Hesperian, 2010). Children living in households with poor sanitation and limited access to clean water have been reported to be 2.7 times more likely to experience stunting compared to those living in households with adequate sanitation (Nisa et al., 2021).

Environmental sanitation, access to clean water, and healthy living behaviors (PHBS) have a significant association with stunting incidence among children under five in Indonesia. PHBS practices, such as proper handwashing with soap and appropriate household waste management, have been shown to reduce the risk of stunting by up to 70% (Amalina et al., 2023). These findings underscore that improving access to clean water must be accompanied by behavioral changes and enhancements in environmental sanitation to ensure that stunting reduction efforts are more effective and sustainable. A review of 16 articles concluded that the use of unimproved water sources and poor environmental sanitation increases the risk of stunting through infectious diseases and impaired nutrient absorption. Conversely, proper water management practices—such as boiling water before consumption and utilizing protected water sources contribute to reducing this risk (Herdinda, 2024).

The Environmental Health Determinants Theory emphasizes that environmental factors including climate change, pollution, and water quality are key determinants of human health. Climate change and water contamination can reduce the availability and quality of clean water, ultimately increasing the risk of waterborne diseases such as diarrhea and parasitic infections (Martins et al., 2024).

Sustainable Development Goal (SDG) 6, which aims to ensure universal access to clean water and adequate sanitation, has shown significant progress; however, disparities in access in remote areas, declining water quality due to pollution, and unsustainable water resource management remain major challenges (Makahanap et al., 2025). Therefore, integrated water resource management, protection of aquatic ecosystems, cross-sector collaboration, and community participation are essential to achieving equitable and sustainable clean water and sanitation management in Indonesia. Effective interventions should not only focus on the construction of water and sanitation infrastructure but also on increasing public awareness and education regarding hygiene practices, water treatment, and clean and healthy living behaviors, particularly during the first 1,000 days of life (Nur'aeni, 2023).

3.5 Relationship between the village development index and stunting prevalence

The results of the Kendall's Tau-b correlation analysis between the Village Development Index (IDM) status and stunting prevalence revealed a strong and significant negative relationship ($r = -0.418$; $p\text{-value} < 0.001$). This finding indicates that the higher the level of village development (classified as developed and independent), the lower the prevalence of stunting in the respective regions. Other studies have shown that the Village Development Index (Indeks Desa Membangun/IDM) has a significant relationship with the prevalence of stunting. This indicates that the higher and more advanced a village's IDM status is, the lower its stunting rate tends to be. The IDM is a multidimensional composite index encompassing social, economic, and environmental aspects (Wicaksono, 2022). These findings reinforce the Sustainable Livelihood Framework approach, suggesting that village development focused on enhancing social, economic, and environmental capacities can strengthen food security and access to basic services (Natarajan et al., 2022).

Table 4. Kendall's tau correlation between village development index and stunting prevalence

Variable	Stunting Prevalence		
	Coefficient (t)	Sig.(2-tailed)	N
Village Development Index	-0,418	0.001	37

The success of stunting prevention largely depends on strengthening household livelihood assets, including financial capital, human capital (maternal education and health), and physical/natural capital (access to clean water and sanitation) (Ghazali, 2023). The Sustainable Livelihoods Framework serves as a crucial operational framework to ensure that stunting interventions go beyond nutritional aspects by enhancing household resilience to vulnerabilities, thereby achieving sustainable health outcomes (Ghazali, 2023; Natarajan et al., 2022).

Other studies have indicated that mothers with low educational attainment tend to have limited knowledge and capacity to meet their children's nutritional needs, while low household income constrains the ability to purchase nutritious food and access adequate healthcare and sanitation services (Jansen et al., 2025). Mothers with low educational levels are 7.2 times more likely to have stunted children compared to those with higher education. Likewise, children who do not regularly attend Posyandu (integrated health service posts) are 3.5 times more likely to be stunted, and those who never attend Posyandu face a 5.2 fold higher risk compared to children who participate regularly (Rahmawati et al., 2020). Children under five from low-income families are nearly four times more likely to experience stunting, while those living in households with smokers face approximately a sixfold higher risk compared to children from non-smoking households. These findings

reinforce that socioeconomic conditions particularly household income and smoking habits play a significant role in determining children's nutritional status and growth outcomes (Khairunnisa, 2024).

Families with low income and low maternal education levels tend to have limited access to nutritious food and adequate nutritional knowledge, making their children more susceptible to stunting (Arifa et al., 2024). Efforts to reduce stunting in Indonesia require comprehensive interventions not only through specific nutrition programs but also by improving economic welfare, expanding access to education, and modifying environmental conditions to achieve the World Health Organization target of reducing stunting prevalence to below 20% (Nugroho et al., 2023).

Stunting prevention must be comprehensive, integrating interventions that address underlying socioeconomic determinants while simultaneously strengthening self-efficacy and community support to promote sustainable preventive behavioral change (Soviyati et al., 2023). By integrating specific (nutrition related) and sensitive (socioeconomic and environmental) interventions, cross-sectoral efforts aim to comprehensively address the root causes of stunting, tailored to the specific needs of each region, while actively engaging the participation of community organizations (Widyawati, 2023).

Based on the 2018 basic health research/*riset kesehatan dasar* (Riskesdas), there were significant differences in stunting risk factors among children aged 6–23 months in Indonesia according to place of residence, with a higher prevalence observed in rural areas (30.8%) compared to urban areas (26.9%) (Ministry of Health of the Republic of Indonesia, 2018). Villages categorized as independent based on IDM tend to have better infrastructure, including improved access to drinking water, sanitation, education, and health services (Ministry of Villages, 2023). Therefore, stunting reduction efforts should focus on holistically improving the IDM through integrated development across all its dimensions, particularly those related to health services, sanitation, and the economic conditions of rural communities.

3.6 Relationship between access to safe drinking water and the village development index with stunting prevalence

The results of the multiple linear regression analysis indicated that the model incorporating two independent variables access to safe drinking water and the Village Development Index (IDM) significantly explained the variation in stunting prevalence (p -value < 0.05). The regression equation obtained was as follows Equation 1.

$$Y = 54.451 - 0.052 (\text{access to safe drinking water}) - 0.378 (\text{VDI status}) \quad (\text{Eq. 1})$$

Each one-point increase in the Village Development Index (IDM) was found to reduce stunting prevalence by 0.378 percentage points, while a 1% increase in access to safe drinking water decreased stunting prevalence by 0.052 percentage points. The standardized Beta coefficients indicated that the IDM had a stronger influence ($\beta = -0.591$) compared to access to safe drinking water ($\beta = -0.091$) on stunting prevalence. Thus, the quality of village development emerged as the dominant factor in reducing stunting rates across provinces. These findings support the Second Hypothesis (H2) and provide empirical evidence that stunting reduction efforts are more strongly influenced by comprehensive village development (as reflected in the Village Development Index, IDM) than by single environmental factors such as access to clean water. An increase in the Village Development Index (IDM) signifies not merely the improvement of a single infrastructure component but the strengthening of the entire Sustainable Livelihood Framework at the village level, including the availability of healthcare services, education, and household economic conditions.

The prevalence of stunting among children under five remains considerably higher in rural areas compared to urban settings, despite an overall decline in national rates (Astari et al., 2023). This significant geographical disparity is driven by a complex set of factors,

including socioeconomic inequalities and unequal accessibility to healthcare services (Shobiha & Yuniasih, 2022). Specifically, the main factors contributing to this disparity include demographic characteristics, environmental conditions, maternal education levels, household economic status (wealth index), and access to healthcare services such as antenatal care and sanitation (Shobiha & Yuniasih, 2022). The dominance of the Village Development Index (IDM) can be attributed to its nature as a multidimensional composite index that encompasses the social, economic, and ecological dimensions of villages.

The village development index may influence stunting prevention through interconnected social, economic, and ecological dimensions. From a social perspective, villages with higher IDM scores tend to have better access to Integrated Health Posts/*Pos Pelayanan Terpadu* (Posyandu), trained health personnel, and nutritional information, which support the implementation of specific nutrition interventions, including supplementary feeding and adequate antenatal care (ANC). Economically, improvements in IDM reflect better village-level socioeconomic conditions that may enhance household purchasing power for nutritious food and reduce vulnerability to economic shocks, thereby helping address the underlying determinants of stunting. From an ecological and environmental perspective, although access to clean water may not be a dominant independent predictor of stunting, the environmental dimension of IDM provides a broader framework for improving sanitation and clean water access through village governance and funding mechanisms. Together, these interconnected dimensions may contribute to more sustainable and comprehensive improvements in community health and stunting prevention (Ministry of Villages and Disadvantaged Regions, 2022; Tambaip et al., 2023).

Effective stunting reduction efforts must adopt a cross-sectoral approach within the framework of the Sustainable Livelihood Strategy, requiring the integration of both specific and sensitive nutrition interventions. This involves the engagement of non-health sectors (such as the Department of Public Works and Housing for clean water and sanitation) and the strengthening of operational-level capacity through active collaboration among community health centers, village administrations, and the family welfare empowerment team/*tim penggerak pemberdayaan dan kesejahteraan keluarga* (TP-PKK), to comprehensively build household resilience (Arso et al., 2024).

Overall, the findings indicate that reducing stunting in Indonesia cannot be achieved solely through nutrition-specific interventions but requires integration with regional development and the strengthening of basic services at the village level. The Ministry of Health, in collaboration with the Ministry of Villages and the National Development Planning Agency/*Badan Perencanaan Pembangunan Nasional* (Bappenas), should enhance coordination in implementing the National Strategy for Accelerating Stunting Reduction through a “convergent nutrition intervention” approach involving the sectors of clean water, sanitation, education, and rural economy. The achievement of a 19.8% stunting prevalence in 2024 is encouraging; however, to reach the 2029 target of 14.2%, accelerated village development is essential, particularly in high-risk regions such as East Nusa Tenggara/*Nusa Tenggara Timur* (NTT), West Java, and North Sumatra (Ministry of Health of the Republic of Indonesia, 2025). The use of secondary data sources such as the Indonesian Nutrition Status Survey (SSGI), the Village Development Index (IDM), and Central Bureau of Statistics (BPS) has proven effective in providing a scientific foundation for more targeted policy planning.

4 Conclusions

This study demonstrated that the village development index status and access to safe drinking water have a significant influence on the prevalence of stunting in Indonesia. The results of the multiple linear regression analysis indicated that improvements in village development quality contribute more substantially to reducing stunting prevalence than improvements in access to safe drinking water. This finding underscores the importance of a holistic and sustainable regional development approach, in which the strengthening of

social, economic, and basic infrastructure capacities in rural areas becomes a key factor in improving community nutritional status.

The findings also reinforce the Social Determinants of Health theory, which posits that social conditions and regional development are primary determinants of public health. The main contribution of this study lies in its empirical evidence of the linkage between village development dimensions and child health, particularly in the context of reducing stunting at the provincial level in Indonesia. Accordingly, the results of this study are expected to provide a scientific basis for policymakers to formulate more integrated interventions across the health, water, and rural development sectors, thereby accelerating the achievement of national stunting reduction targets as outlined in the 2025–2029 National Medium-Term Development Plan (RPJMN).

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Author Contribution

Conceptualization, D.S.N.; Methodology, D.S.N.; Formal Analysis, D.S.N.; Data Curation, D.S.N.; Writing – Original Draft Preparation, D.S.N.; Writing – Review & Editing, D.S.N.; Visualization, D.S.N.; Project Administration, D.S.N.

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Ethical Review Board Statement

Not available.

Informed Consent Statement

Not available. This study did not involve human participants or the collection of individual-level data. All data were obtained from publicly available secondary sources (SSGI, IDM, and BPS 2024).

Data Availability Statement

Survei Status Gizi Indonesia (SSGI) 2024 (<https://www.badankebijakan.kemkes.go.id/survei-status-gizi-indonesia-ssgi-2024/>) — Ministry of Health of the Republic of Indonesia. Indeks Desa Membangun (IDM) 2024 (<https://idm.kemendes.go.id/>) — Ministry of Villages, Development of Disadvantaged Regions, and Transmigration. Statistics Indonesia (BPS) 2024 (<https://www.bps.go.id/>) — National socioeconomic and demographic data. No new data were created or analyzed in this study beyond these publicly available sources.

Conflicts of Interest

The author declare no conflict of interest. The study was conducted independently without any financial or institutional influence.

Declaration of Generative AI Use

During the preparation of this work, the author used ChatGPT (OpenAI, GPT-5) to assist in language structuring and refinement. After using this tool, the author reviewed, verified, and edited the content as needed and takes full responsibility for the final content of the

publication.

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