



Stunting among Under-Five Children in Semarang Regency: Evidence from a Case-Control Study on Maternal KAP, Sanitation, and Early Feeding

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Abstract

Stunting is a significant public health issue with enduring impacts on cognitive development, productivity, and susceptibility to chronic diseases. This study aims to quantify determinants of stunting among children aged 6–59 months in Semarang Regency, Central Java, Indonesia, through a case-control study design. A total of 251 children (49 stunted cases and 202 controls) aged 6–59 months were enrolled between September and October 2024 from two purposively selected primary health centers. Data included biological, environmental, and maternal knowledge-attitude-practice (KAP) variables. Chi-square tests were used for bivariate analysis, and variables with $p < 0.25$ were included in a multivariable logistic regression model. Bivariate analysis indicated that diarrheal infection, short birth length, lack of exclusive breastfeeding, poor sanitation, inadequate feeding practices, low maternal knowledge, negative maternal attitudes, and poor preventive behaviors were significantly associated with increased odds of stunting ($p < 0.05$). Multivariable analysis revealed that a negative maternal attitude had the strongest association with stunting (AOR=2.4; 95% CI: 1.2–4.6), alongside other independently associated factors. These findings suggest that stunting is shaped by interconnected biological, environmental, and psychosocial factors. Interventions should integrate behavior change communication and WASH improvements with nutrition-specific actions. Results should be interpreted as associative and not causal due to the case-control study design.

Introduction

Stunting is a widespread public health issue linked to chronic undernutrition and insufficient care during the first 1,000 days of life (Jalaludin *et al.*, 2025). As per the 2023 UNICEF/WHO/World Bank estimates, about 22.3% of children under five globally are stunted, amounting to 148 million children whose developmental potential is at risk (UNICEF *et al.*, 2023). Most of the global burden of stunting is concentrated among children living in low- and middle-income countries, particularly in South Asia and Sub-Saharan Africa (Benjamin-

Chung *et al.*, 2023). In Indonesia, stunting highlights not only prolonged nutritional inadequacy but also deep-rooted disparities in access to essential services, including food, health, sanitation, and hygiene (Pusdatin, 2018).

Despite longstanding efforts, stunting remains a developmental obstacle in Southeast Asia. In Indonesia, which bears a considerable stunting burden, the prevalence dropped from 27.7% in 2019 to 21.6% in 2022, showing progress toward the 2024 national goal of 14% and the SDG 2.2 target to end malnutrition

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by 2030 (Halli *et al.*, 2022). However, rates still exceed WHO's recommended threshold of 20%, indicating that current interventions may not fully address underlying community and household-level causes (World Health Organization, 2023). Moreover, national statistics may obscure subnational inequalities, and highlighting the necessity to explore determinants in localized settings such as Semarang Regency.

Stunting in children begins in the early stages of life, up to the first three, or four year (Fleming *et al.*, 2018) (Stephenson *et al.*, 2018). The first 1000 days of life are a crucial period for determining a child's future development, both in physical and mental health (van Zyl & van Wyk, 2021). In low-resource settings, the first thousand days of life, including the prenatal period, are considered the critical window to intervene to prevent stunting (Martorell, 2017). Intrauterine growth restriction and preterm birth are strongly associated with stunting at 24 months of age (Christian *et al.*, 2013). Most linear growth faltering occurs by the age of 2 years, and 70% of absolute length deficits until the age of 5 years occur before the age of 2 years. Children who experience linear growth faltering before the age of 2 years can experience catch-up growth at older ages, particularly with improvements to their nutrition, health, and environment (Aizawa, 2020) (Georgiadis *et al.*, 2017). However, the extent of catch-up growth depends on the timing and severity of early-life linear growth faltering (Gausman *et al.*, 2019).

The impact of stunting on children includes short-term and long-term impacts, including increased morbidity and mortality, stunted child development, impaired learning, and working capacity, increased risk of infectious and non-communicable diseases, increased fat accumulation, especially in the abdomen, low-fat oxidation, low energy expenditure, insulin resistance, and increased risk of diabetes, hypertension, and dyslipidemia (Akseer *et al.*, 2022) (Soliman *et al.*, 2021). Semarang Regency, located in Central Java, continues to face a rise in stunting prevalence despite multiple ongoing nutrition initiatives. With its urban-rural demographic mix and varied socio-economic and healthcare access conditions, the region is an ideal context for

exploring determinants of stunting. While numerous national studies exist, few employ analytical case-control methodologies to assess the interaction between maternal behavior, sanitation, and child feeding practices at the subnational level (Krisseptiana & Martadi, 2024).

Accordingly, this study aims to identify the determinants of stunting among children aged 6–59 months in Semarang Regency using a case-control design. This approach compares stunted and non-stunted children to uncover modifiable risk factors, including maternal knowledge, attitudes, preventive practices, and household environmental conditions, while adjusting for biological variables (Al-Ayubi & Ariyanti, 2021). The central hypothesis posits that these behavioral and environmental factors are independently associated with the risk. The novelty of this research is that the occurrence of stunting is shaped by interrelated biological, environmental, and psychosocial factors. The central hypothesis posits that these behavioral and environmental factors are independently associated with the risk.

Methodology

This study adopted a case-control design to explore determinants of stunting among children aged 6–59 months in Semarang Regency, Central Java, Indonesia. The study was conducted between September and October 2024 in two primary health centers, Kalongan and Pringapus. Selected purposively for the persistently high stunting prevalence, as reported by recent district health surveillance data. This design was chosen for its efficiency in examining multiple potential risk factors associated with stunting, a relatively uncommon but critical outcome. The study population included children aged 6–59 months and their primary caregivers. The minimum sample size ($n=47$) was estimated using a standard case-control formula, with parameters $Z_{\alpha} = 1.96$ (95% CI), $Z_{\beta} = 0.84$ (80% power), an odds ratio of 3.3, and assumed exposure proportions derived from previous literature. A total of 330 children were initially screened for height-for-age Z-scores (HAZ). Of these, 52 were stunted, and 49 were randomly chosen as cases after excluding 3 with incomplete data. Among

Table 1. Operational Definitions of Key Variables

Variables	Measurements/Definition	Classification
Stunting status	HAZ < -2 SD based on WHO 2006 Growth Standards	Stunted / Non-stunted
Exclusive breastfeeding	Child exclusively breastfed for 6 months	Yes / No
Sanitation	Compliance with waste, wastewater, and clean water standards	Good / Poor
Dietary habits	Frequency, diversity, and scheduling of meals	Good ($\geq 75\%$) / Poor ($< 75\%$)
Maternal knowledge	Correct responses on 20 nutrition-related questions	Good ($\geq 55\%$) / Poor ($< 55\%$)
Maternal attitude	Positive responses to 25 attitude items on stunting prevention	Good ($\geq 55\%$) / Poor ($< 55\%$)
Preventive practices	Reported behaviors for stunting prevention	Good ($\geq 55\%$) / Poor ($< 55\%$)

278 non-stunted children, 202 were selected as controls using simple random sampling, establishing an approximate 1:4 case-control ratio. Data were collected using a structured and pretested questionnaire administered to caregivers. The tool covered sociodemographic profiles, child health, feeding practices, and maternal knowledge, attitudes, and stunting prevention behaviors. Content validity was assessed through expert panel review, and domain-specific reliability was evaluated using Cronbach's alpha, which yielded an overall score of 0.753, indicating satisfactory/ internal consistency.

Data analysis was performed using IBM SPSS Statistics version 16. Descriptive statistics were computed for participant characteristics. Chi-square tests were used to examine bivariate associations, and variables having $p < 0.25$ were included in a multivariate logistic regression model to identify independent predictors. Model diagnostics included the Hosmer-Lemeshow test for goodness-of-fit and variance inflation factors (VIF) to detect multicollinearity. Significant predictors were identified based on p -values < 0.05 , and results were expressed as adjusted odds ratios (AOR) with 95% confidence intervals (CI). Ethical approval for this study was obtained from the Ethics Committee of Ngudi Waluyo University (No. 566/KEP/EC/UNW/2024). Permissions were also granted by the primary health

center Kalongan (No. 400.7.22.1/069.1/2024) and the primary health center Pringapus (No. 400.14.5.4/1945/2024). Informed consent was obtained from all participating mothers or caregivers prior to data collection, and confidentiality of respondent information was strictly maintained.

Results and Discussion

A total of 251 respondents were included, comprising 49 stunted and 202 non-stunted children. Table 2 presents their socio-demographic and biological characteristics. The majority of children were female (54.2%), and 42% were aged 6–24 months. A high level of parental education (68.6%) was observed. Among children, 23.9% had experienced diarrheal infection in the last three months, 24.7% had short birth length, and 23.1% were not exclusively breastfed. Additionally, 24.3% of households had poor sanitation, and 23.9% of mothers exhibited inadequate feeding practices. Psychosocial risk factors included low maternal knowledge (21.9%), negative attitudes (25.9%), and poor preventive behaviors (24.7%). These findings illustrate a convergence of biological, environmental, and psychosocial vulnerabilities.

Chi-square analysis identified several variables significantly associated with stunting (Table 3). These included diarrheal infection ($p=0.031$), short birth length ($p=0.046$),

Table 2. Socio-demographic, Biological, and Behavioral Characteristics of Respondents (N=251)

Variables	Categories	n (%)
Sex	Male	115 (45.8)
	Female	136 (54.2)
Child Age (months)	6–24	106 (42.0)
	25–48	98 (39.0)
	49–59	47 (19.0)
Parental Education	Low	79 (31.5)
	High	172 (68.6)
Diarrheal infection	Yes	60 (23.9)
	No	191 (76.1)
Birth length	Short	62 (24.7)
	Normal	189 (75.3)
Exclusive breastfeeding	No	58 (23.1)
	Yes	193 (76.9)
Sanitation	Poor	61 (24.3)
	Good	190 (75.7)
Feeding habits	Poor	60 (23.9)
	Good	191 (76.1)
Maternal knowledge	Poor	55 (21.9)
	Good	196 (78.1)
Maternal attitude	Negative	65 (25.9)
	Positive	186 (74.1)
Preventive practices	Poor	62 (24.7)
	Good	189 (75.3)

Source: Primary Data, 2024

non-exclusive breastfeeding ($p=0.030$), poor sanitation ($p=0.014$), inadequate feeding habits ($p=0.040$), low maternal knowledge ($p=0.027$), negative maternal attitude ($p=0.013$), and poor preventive practices ($p=0.018$). Odds ratios ranged from 2.0 to 2.9, indicating these factors roughly doubled the risk of stunting.

Multivariate logistic regression stressed negative maternal attitude as the strongest independent predictor of stunting (AOR=2.4, 95% CI: 1.2–4.6). Other factors, such as diarrheal, short birth length, lack of exclusive breastfeeding, poor sanitation, inadequate feeding practices, and low maternal knowledge, remained statistically significant. These results underscore the multifactorial and interrelated determinants of child growth outcomes. Children with a history of diarrheal infection had more than twice the risk of stunting compared

to those without such a history, suggesting that repeated enteric infections contribute to chronic undernutrition through nutrient malabsorption and intestinal inflammation. Similarly, short birth length doubled the risk of stunting, underscoring the importance of maternal nutrition and prenatal care. Lack of exclusive breastfeeding emerged as a strong behavioral determinant (OR=2.9), indicating that early nutritional practices critically shape growth trajectories. Poor household sanitation and feeding further amplified the risk, reflecting the multidimensional nature of environmental and behavioral determinants. The results of this study align with research showing that sanitation has a significant positive relationship with the risk of stunting ($B = 1.060$, $p < 0.001$) (Najib *et al.*, 2024).

Among psychosocial variables,

Table 3. Bivariate Associations Between Independent Variables and Stunting

Variables	p-value	OR	95% CI
Diarrheal infection	0.031	2.2	1.12–4.33
Short birth length	0.046	2.0	1.10–4.10
No exclusive breastfeeding	0.030	2.9	1.50–5.80
Poor sanitation	0.014	2.4	1.23–4.70
Poor feeding habits	0.040	2.7	1.40–5.40
Poor maternal knowledge	0.027	2.2	1.10–4.50
Negative maternal attitude	0.013	2.4	1.20–4.60
Poor preventive practice	0.018	2.3	1.20–4.50

Source: Primary Data, 2024

maternal knowledge, attitudes, and practices (KAP) demonstrated consistent associations with stunting. Mothers with limited understanding of stunting prevention or negative attitudes toward health promotion were more likely to engage in inadequate feeding or hygiene practices. Adjusted OR values were interpreted within the multivariate framework to capture the independent influence of each psychosocial factor. The finding that maternal attitude had the highest odds ratio highlights the role of behavioral psychology in shaping child nutrition outcomes. This supports the argument that, beyond biomedical interventions, behavioral and educational strategies are essential to achieving sustainable stunting reduction.

Eight variables were significantly associated with stunting among children aged 6–59 months in Semarang Regency. The strongest determinant was maternal attitude, followed by sanitation, breastfeeding status, and diarrheal infection. Biological, environmental, and psychosocial dimensions were all implicated, demonstrating that stunting is a multifactorial phenomenon requiring multisectoral intervention. The findings align with previous studies across Indonesia and other low- and middle-income countries, reinforcing that stunting reduction efforts should integrate maternal empowerment, hygiene, and early-life nutrition programs. The present study revealed that stunting among children aged 6–59 months in Semarang Regency is influenced by an interplay of biological, behavioral, and environmental determinants. Eight variables were significantly associated with

stunting, including diarrheal infection, short birth length, lack of exclusive breastfeeding, poor sanitation, inadequate feeding habits, low maternal knowledge, negative maternal attitudes, and poor preventive practices. Among these, maternal attitude showed the strongest adjusted association rather than a causal effect, underscoring the crucial role of psychosocial and behavioral dimensions in stunting prevention. All inferences reflect associations from a case-control design and should not be interpreted as proof of causality. These findings affirm that stunting is not merely a biological or nutritional outcome but a multidimensional phenomenon shaped by the complex interactions between maternal behavior, household environment, and socio-economic conditions.

The association between diarrheal infection and stunting aligns with global evidence demonstrating that recurrent enteric infections impair nutrient absorption and intestinal integrity, leading to chronic undernutrition. A multi-country analysis by (Danaei *et al.*, 2016) reported an association between repeated diarrheal episodes and higher stunting prevalence; figures are context-dependent and should be interpreted circumspectly. The results of this study similarly suggest that diarrheal prevention should remain a central focus of child health interventions. Likewise, the finding that short birth length was associated with approximately twofold higher odds of stunting corroborates studies in Bangladesh and Ethiopia, where intrauterine growth restriction and low maternal nutrition were the major antecedents

of growth faltering (Rahman *et al.*, 2023). These consistencies strengthen the biological rationale that maternal health during pregnancy directly influences postnatal growth trajectories.

In contrast, this study diverges from findings in some Indonesian provinces where maternal education or household income are identified as the primary determinant of stunting (Subarkah *et al.*, 2016). The difference may stem from contextual variations in socioeconomic inequality and public health infrastructure. Semarang Regency, for instance, has relatively better access to health services, which may shift the relative importance toward behavioral and environmental correlates; however, residual confounding cannot be excluded. The prominence of maternal attitude as the strongest adjusted predictor is a critical contribution of this study. According to the Theory of Planned Behavior (Hill *et al.*, 1977). Individual attitudes shape behavioral intentions and subsequent actions. Mothers with negative attitudes toward stunting prevention may underestimate its long-term consequences, thereby neglecting essential practices such as exclusive breastfeeding, hygiene maintenance, and timely health visits. Similar behavioral patterns have been observed in Nepal and Nigeria, where mothers' risk perception and attitudes toward nutrition interventions were strongly correlated with child growth outcomes (Arora & Gill, 2022).

The present finding reinforces the need to integrate behavioral change communication (BCC) into stunting reduction programs. Educational efforts focusing solely on information transfer may not suffice; interventions must also reshape maternal beliefs and motivations through participatory approaches, peer support, and culturally sensitive counseling. These recommendations are framed as programmatic implications derived from associations, not as definitive causal prescriptions. This approach aligns with the UNICEF Communication for Development strategy, which emphasizes attitude transformation as a prerequisite for sustained behavior change. The finding that non-exclusive breastfeeding was associated with nearly threefold higher odds of stunting is consistent with extensive literature confirming

the protective effects of breastfeeding on growth and immunity. Exclusive breastfeeding provides optimal nutrition and immunological defense during the first six months of life, reducing exposure to contaminated foods and infections. Studies from Kenya and India similarly report that children who were not exclusively breastfed were about 2.5–3.0 times more likely to be stunted (Maingi *et al.*, 2023). However, in many communities, early introduction of complementary foods remains prevalent due to cultural beliefs, maternal workload, and lack of family support. Addressing these barriers requires community-based interventions that engage fathers, grandmothers, and local leaders to support optimal infant feeding practices.

Environmental determinants, particularly household sanitation, were also found to significantly associate with stunting. This finding reinforces the WASH–nutrition nexus, which links inadequate water, sanitation, and hygiene to environmental enteric dysfunction (EED) and subsequent nutrient malabsorption. Evidence suggests that sanitation improvements are linked with lower stunting prevalence, though effect sizes vary across settings (Spears *et al.*, 2019). Inadequate access to safe drinking water, poor sanitation, and substandard housing are significantly correlated with a higher prevalence of stunting (Kurniawan *et al.*, 2025). Children who have a history of infectious diseases are at risk of stunting by 2.2 times higher than children who do not have a history of infectious diseases after being controlled by child age, gender, low birth weight (LBW), short birth length (SBL), and toilet sanitation (Nugroho *et al.*, 2023) (Tyas & Setyonaluri, 2022) (Wulandary & Sudiarti, 2024). Environmental factors also influence the incidence of stunting, including sanitation. In Semarang, where 24.3% of households had poor sanitation, this pathway remains a critical intervention point. The results underscore that nutritional interventions must be complemented by infrastructural and environmental health improvements (Najib *et al.*, 2023). Programmatic interpretations are offered cautiously, given the observational design.

Inadequate feeding habits emerged as another modifiable determinant. Poor

dietary diversity and irregular meal frequency deprive children of essential micronutrients necessary for growth. These findings align with the Minimum Dietary Diversity (MDD) framework, which identifies consumption of at least five food groups as a proxy for nutrient adequacy (World Health Organization, 2023). Previous studies in Indonesia and the Philippines have reported similar patterns, where monotonous diets dominated by rice and limited animal-source foods contribute to persistent growth failure (Torlesse *et al.*, 2016). Inadequate micronutrient intake is a significant contributor to malnutrition (Muflih *et al.*, 2024). This emphasizes the importance of promoting locally available, yet affordable, nutrient-rich foods through nutrition-sensitive agricultural and educational initiatives.

The role of maternal knowledge and preventive practices complements the finding on attitude, suggesting a dynamic Knowledge–Attitude–Practice (KAP) relationship in stunting prevention. Mothers with insufficient knowledge are less likely to recognize stunting as a preventable condition, resulting in delayed healthcare utilization and inadequate feeding responses. However, as behavioral theories suggest, knowledge alone does not automatically translate into practice; it must be coupled with positive attitudes and enabling environments. Accordingly, programmatic implications focus on strengthening enabling contexts alongside education, without inferring direct causality. One of the determining factors for the success of stunting control is family independence in managing toddlers' health by utilizing smartphone applications. Smartphone Application “Family Care Stunting” is a potential tool for better education, monitoring, and decision-making, especially for families facing the challenges of stunting and comorbidities in children (Listyarini *et al.*, 2025). Stunting protective factors are: prevention of LBW (Low Birth Weight), limiting the number of children to 3, improved parenting for the boys, prevention of young-age pregnancy, and stunting in the female adolescent. Other factors are completing immunization, improving maternal education and the health services of children under five in rural areas, and improving Fe consumption for

pregnant mothers (Simbolon *et al.*, 2019).

The coexistence of biological (birth length, infection), environmental (sanitation), and behavioral (knowledge, attitude, practice) determinants in this study confirms the multidimensional nature of stunting as conceptualized by the UNICEF framework. Stunting does not occur in isolation but within an ecosystem of risk factors that operate across multiple levels from the maternal to the community scale. This finding supports multilevel analyses conducted in Ethiopia and Tanzania, which revealed that community sanitation and maternal behavior jointly explained more than half of the variation in child growth outcomes (Gebru *et al.*, 2022). Hence, interventions must be integrative, addressing proximal causes while simultaneously mitigating the structural determinants that sustain undernutrition.

From a policy perspective, these findings hold significant implications for the implementation of Indonesia's National Strategy to Accelerate Stunting Reduction. While the national framework emphasizes nutrition-specific interventions such as micronutrient supplementation and breastfeeding promotion, this study highlights the importance of scaling up behavioral and environmental components. In particular, programs designed to address maternal attitudes and WASH may be promising, but recommendations are made, acknowledging that the observed relationships are associative and not causal. Local governments could adopt community-based models such as *Posyandu Plus*, which integrates growth monitoring, hygiene education, and behavioral counseling under a single service platform. Furthermore, collaboration between the Ministry of Health, the Ministry of Public Works, and the Ministry of Education is essential to create synergy across sectors. This multi-sector integration echoes the global call for *nutrition-sensitive governance*, ensuring that infrastructure development, maternal education, and social protection all contribute to reducing the stunting prevalence. These recommendations are aligned with Indonesia's Medium-Term Development Plan 2020–2024 and the global SDG 2.2 target.

The present study contributes to the

literature by employing a case-control design that identifies independent determinants of stunting within a subnational context. This analytical approach enables better control of confounders and offers stronger inferential validity than descriptive cross-sectional designs commonly used in previous studies. However, several limitations warrant consideration. First, the study relied on maternal recall for variables such as exclusive breastfeeding and infection history, which may introduce recall bias. Second, the cross-sectional nature of exposure measurement precludes establishing temporal causality. Third, the study did not include dietary diversity scores or biochemical indicators, which could provide more granular insights into nutritional status. Additionally, measurement error in composite KAP indices and potential selection bias from two purposively selected health centers may limit generalizability. Future research should adopt longitudinal or mixed-method designs to capture temporal dynamics and explore behavioral change in greater depth. Qualitative studies may also help elucidate how cultural norms and family structures influence maternal attitudes and feeding practices. In addition, expanding similar analytical frameworks to other regions of Indonesia will facilitate comparative analysis and evidence-based prioritization of interventions. Future analyses should also report full multivariable model diagnostics and consider hierarchical or multilevel designs to account for community-level effects.

Overall, this study underscores that stunting prevention requires more than nutritional supplementation; it demands behavioral, environmental, and social transformation. Within the limits of observational evidence, Maternal attitudes and preventive practices showed strong associations with children's nutritional outcomes through daily caregiving and health decisions. The findings reinforce the applicability of the Theory of Planned Behavior and UNICEF's conceptual model in explaining the multifaceted causes of stunting in developing contexts. By situating behavioral change alongside biomedical and infrastructural strategies, this study offers an integrative pathway toward sustainable

stunting reduction. Policymakers, therefore, should adopt a holistic approach that empowers mothers, strengthens sanitation systems, and ensures equitable access to health and nutrition services. These strategies are presented as evidence-informed priorities derived from associative findings, and timelines or targets should be interpreted with caution, given that national prevalence goals may evolve over time.

Conclusion

This study offers context-specific, observational evidence identifying maternal attitude as the strongest behavioral determinant independently associated with stunting among children aged 6–59 months in Semarang Regency, Indonesia. Utilizing the UNICEF Conceptual Framework and the Theory of Planned Behavior, the study shifts the focus beyond biomedical and nutritional domains to highlight psychosocial and environmental influences. The findings suggest non-causal associations, in which maternal attitude, knowledge, and practices align with sanitation quality, breastfeeding behavior, and infection history to affect child growth outcomes. The results emphasize that effective stunting prevention should be a multisectoral strategy integrating behavioral transformation with environmental enhancements. Interventions such as behavioral change communication, maternal empowerment, and WASH promotion—especially through platforms like Posyandu Plus—should be considered as evidence-informed yet non-causal strategies. Recognized limitations include recall bias, the cross-sectional nature of exposure measurement, potential misclassification in composite KAP indicators, and selection bias due to purposive site sampling. Despite these constraints, the consistency of associations supports further longitudinal investigation. By identifying mothers' attitudes and sanitation as key entry points, this study provides practical, evidence-informed insights for strengthening Indonesia's National Strategy to Accelerate Stunting Reduction. These findings also support the broader SDG 2.2 goal of ending malnutrition and advocating for integrated, behavior-centered public health interventions. However, timelines and targets must remain

flexible, and conclusions should not be misconstrued as evidence of causality.

References

- Aizawa, T., 2020. Trajectory of Inequality of Opportunity in Child Height Growth: Evidence from the Young Lives Study. *Demographic Research*, 42(7).
- Akseer, N., Tasic, H., Nnachebe, O.M., Wigle, J., Rajakumar, R., Sanchez-Hernandez, D., Akuoku, J., Black, R.E., Horta, B.L., Nwuneli, N., Shine, R., Wazny, K., Japra, N., Shekar, M., & Hoddinott, J., 2022. Economic Costs of Childhood Stunting to the Private Sector in Low- and Middle-Income Countries. *EClinicalMedicine*, 45.
- Al-Ayubi, M.T.A., & Ariyanti, F., 2021. Determinants of Stunting in Children Aged 6-59 Months in Glagah Sub-District, Indonesia. *Jurnal Berkala Epidemiologi*, 9(3).
- Arora, T.S., & Gill, S., 2022. Impact of Corporate Tax Aggressiveness on Firm Value: Evidence from India. *Managerial Finance*, 48(2), pp.313–333.
- Benjamin-Chung, J., Mertens, A., Colford, J.M., Hubbard, A.E., Van Der Laan, M.J., Coyle, J., Sofrygin, O., Cai, W., Nguyen, A., Pokpongkiat, N.N., Djajadi, S., Seth, A., Jilek, W., Jung, E., Chung, E.O., Rosete, S., Hejazi, N., Malenica, I., Li, H., Hafen, R., Subramoney, V., Häggström, J., Norman, T., Brown, K.H., Christian, P., & Arnold, B.F., 2023. Early-Childhood Linear Growth Faltering in Low- and Middle-Income Countries. *Nature*, 621(7979).
- Christian, P., Lee, S.E., Angel, M.D., Adair, L.S., Arifeen, S.E., Ashorn, P., Barros, F.C., Fall, C.H.D., Fawzi, W.W., Hao, W., Hu, G., Humphrey, J.H., Huybregts, L., Joglekar, C.V., Kariuki, S.K., Kolsteren, P., Krishnaveni, G.V., Liu, E., Martorell, R., Osrin, D., Persson, L.A., Ramakrishnan, U., Richter, L., Roberfroid, D., Sania, A., Kuile, F.O.T., Tielsch, J., Victora, C.G., Yajnik, C.S., Yan, H., Zeng, L., & Black, R.E. 2013. Risk of Childhood Undernutrition Related to Small-For-Gestational Age and Preterm Birth in Low- And Middle-Income Countries. *International Journal of Epidemiology*, 42(5).
- Danaei, G., Andrews, K.G., Sudfeld, C.R., Fink, G., McCoy, D.C., Peet, E., Sania, A., Smith Fawzi, M.C., Ezzati, M., & Fawzi, W.W., 2016. Risk Factors for Childhood Stunting in 137 Developing Countries: A Comparative Risk Assessment Analysis at Global, Regional, and Country Levels. *PLoS Medicine*, 13(11).
- Fleming, T.P., Watkins, A.J., Velazquez, M.A., Mathers, J.C., Prentice, A.M., Stephenson, J., Barker, M., Saffery, R., Yajnik, C.S., Eckert, J.J., Hanson, M.A., Forrester, T., Gluckman, P.D., & Godfrey, K.M., 2018. Origins of Lifetime Health Around the Time of Conception: Causes and Consequences. *The Lancet*, 391(10132).
- Gausman, J., Kim, R., & Subramanian, S.V., 201). Stunting Trajectories from Post-Infancy to Adolescence in Ethiopia, India, Peru, and Vietnam. *Maternal and Child Nutrition*, 15(4).
- Gebru, K.M., Rammelt, C., & Leung, M., 2022. Paradoxes of Inclusion: Adverse Effects of Inclusive Interventions in Northern Ethiopia. *European Journal of Development Research*, 34(5).
- Georgiadis, A., Benny, L., Duc, L.T., Galab, S., Reddy, P., & Woldehanna, T., 2017. Growth Recovery and Faltering Though Early Adolescence in Low- and Middle-Income Countries: Determinants and Implications for Cognitive Development. *Social Science and Medicine*, 179, pp.81–90.
- Halli, S.S., Biradar, R.A., & Prasad, J.B., 2022. Low Birth Weight, the Differentiating Risk Factor for Stunting among Preschool Children in India. *International Journal of Environmental Research and Public Health*, 19(7).
- Hill, R.J., Fishbein, M., & Ajzen, I., 1977. Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research. *Contemporary Sociology*, 6(2).
- Jalaludin, M.Y., Fauzi, M.D., Sidiartha, I.G.L., John, C., Aviella, S., Noverly, E., Permatasari, A., & Muhandi, L., 2025. Addressing Stunting in Children Under Five: Insights and Opportunities from Nepal, Bangladesh, and Vietnam—A Review of Literature. *Children*, 12(5), pp.1–19.
- Krisseptiana., & Martadi, N.S.D., 2024. Mitigating Stunting in Semarang City, Indonesia: A Comprehensive Approach to Better Health and Well-Being. *Jurnal Promkes*, 12(2), pp.218–228.
- Kurniawan, R., Widyastuti, L., Alimoeso, S., Fathonah, S., Diaini, M., Kodir, M., Fine, W., Prawiti, O.A., & Fadhillah, H.F., 2025. Families at Risk of Stunting and the Prevalence of Stunting in Indonesia: An Ecological Study. *Jurnal Kesehatan Masyarakat*, 21(1), pp.225–236.
- Listyarini, A.D., Handayani, O.W.K., Yuniastuti, A., & Farida, E., 2025. Development of

- a Smartphone Application "Family Care Stunting" to Increase the Independence of Families with Stunting Toddlers and Comorbid Diseases. *Jurnal Kesehatan Masyarakat*, 21(2), pp.454–464.
- Maingi, E., Nyerere, A., & Makobe, C., 2023. Phenotypic and Genotypic Characterization of Extended Spectrum Beta-Lactamases Producing Bacteria Causing Urinary Tract Infections among Expectant Women Attending Antenatal Clinic at Ruiru Sub County Hospital, Kenya. *Advances in Microbiology*, 13(12).
- Martorell, R., 2017. Improved Nutrition in the First 1000 Days and Adult Human Capital and Health. *American Journal of Human Biology*, 29(2).
- Muflih, M., Widaryanti, R., & Erwanto, R., 2024. Identifying Malnutrition Risks in Vulnerable Groups is Key to Complementary Therapy In Health Crises. *Jurnal Kesehatan Masyarakat*, 20(2), pp.269–279.
- Najib., Giyarsih, S.R., Listyaningsih, U., & Nawawi., 2024. Impact Sanitation, Childbearing Age, Number of Children, Mother's Age with the Risk of Stunting in Children. *Jurnal Kesehatan Masyarakat*, 20(2), pp.329–338.
- Najib., Rum-Giyarsih, S., Listyaningsih, U., & Nawawi., 2023. Analysis of Feeding Behavior and Family Food Security as a Stunting Risk Factor in Semarang City. *Kemas*, 19(2).
- Nugroho, E., Wanti, P.A., Suci, C.W., Raharjo, B.B., & Najib., 2023. Social Determinants of Stunting in Indonesia. *Kemas*, 18(4).
- Pusdatin., 2018. *Topik Utama: Situasi Balita Pendek (Stunting) di Indonesia*. Soetjiningsih. *Tumbuh Kembang Anak*. Penerbit Buku Kedokteran EGC.
- Rahman, H., Rahmah, M., & Saribulan, N., 2023. Upaya Penanganan Stunting Di Indonesia: Analisis Bibliometrik dan Analisis Konten. *Jurnal Ilmu Pemerintahan Suara Khatulistiwa (JIPSK)*, VIII(1).
- Simbolon, D., Suryani, D., & Yorita, E., 2019. Prediction Model and Scoring System in Prevention and Control of Stunting Problems in Under Five-Year-Olds in Indonesia. *Kemas*, 15(2).
- Soliman, A., De Sanctis, V., Alaraj, N., Ahmed, S., Alyafei, F., Hamed, N., & Soliman, N., 2021. Early and Long-Term Consequences of Nutritional Stunting: From Childhood to Adulthood. *Acta Biomedica*, 92(1).
- Spears, N., Lopes, F., Stefansdottir, A., Rossi, V., De Felici, M., Anderson, R.A., & Klinger, F.G., 2019. Ovarian Damage from Chemotherapy and Current Approaches to Its Protection. *Human Reproduction Update*, 25(6).
- Stephenson, J., Heslehurst, N., Hall, J., Schoenaker, D.A.J.M., Hutchinson, J., Cade, J.E., Poston, L., Barrett, G., Crozier, S.R., Barker, M., Kumaran, K., Yajnik, C.S., Baird, J., & Mishra, G.D., 2018. Before the Beginning: Nutrition and Lifestyle in the Preconception Period and Its Importance for Future Health. *The Lancet*, 391(10132).
- Subarkah, T., Nursalam., & Rachmawati., 2016. Pola Pemberian Makan Terhadap Peningkatan Status Gizi pada Anak Usia 1-3 Tahun. *J. Injec*, 1(2), pp.146.
- Torlesse, H., Cronin, A.A., Sebayang, S.K., & Nandy, R., 2016. Determinants of Stunting in Indonesian Children: Evidence from a Cross-Sectional Survey Indicate a Prominent Role for the Water, Sanitation and Hygiene Sector in Stunting Reduction. *BMC Public Health*, 16(1).
- Tyas, A.P., & Setyonaluri, D., 2022. Association between Maternal Mental Health and Child Stunting in Indonesia. *Kemas*, 17(3).
- UNICEF, WHO, & WORLD BANK., 2023. *Level and Trend in Child Malnutrition*. World Health Organization.
- Van Zyl, C., & Van Wyk, C., 2021. Exploring Factors that Could Potentially Have Affected the First 1000 Days of Absent Learners in South Africa: A Qualitative Study. *International Journal of Environmental Research and Public Health*, 18(5), pp.1–19.
- World Health Organization., 2023. *UNICEF/WHO/The World Bank Group Joint Child Malnutrition Estimates: Key Findings of the 2023 Edition*.
- Wulandary, W., & Sudiarti, T., 2024. Stunting on Children Aged 6 – 23 Months in East Nusa Tenggara Province. *Kemas*, 19(4).