

Original Research

Received 02 June 2026

Revised 25 July 2026

Accepted 10 Aug 2026

Natural Resources for Human
Health 2026, Vol. 6 (15s): 860–868

KEYWORDS:

Stunting, Prediction model,
Regression logistics, WASH,
Infection

A Prediction Model of Stunting Incidents Based on Water, Sanitation, Hygiene (WASH), House Conditions, And Infections in Toddlers in Tulang Bawang District, Lampung Province

Yenny Puspitasari¹, Dyah Wulan Sumekar Rengganis Wardani²,
Arief Darmawan³, Tugiyono¹

¹Doctoral Program of Environmental Science, Graduate Program, University of Lampung, Indonesia

²Department of Public Health, Faculty of Medicine, University of Lampung, Indonesia

³Department of Forestry, Faculty of Agriculture, University of Lampung, Indonesia
Email address: dyah.wulan@fk.unila.ac.id

ABSTRACT: Introduction: Stunting is a chronic nutritional problem that affects the growth and development of toddlers. Environmental factors such as water, sanitation, hygiene (WASH), home conditions, and infection play an important role, but prediction models specific to the level of regency are still limited. Objective: This study aimed to develop a predictive model for stunting in toddlers aged 0–59 months in the Regency of Tulang Bawang in 2024 based on WASH.

Materials and Methods: An observational analysis with a cross-sectional approach using secondary data from e-PPGBM and Data Collection Family 2024 ($n = 1,287$ stunted toddlers after exclusion). The independent variables included access to drinking water, sanitation, hygiene, garbage and waste management, housing conditions, and history of infection. Bivariate (chi-square) and multivariate (regression) logistic analyses were performed using SPSS.

Results: The prevalence of stunting was 18.3%. The final model showed that unsafe drinking water access (aOR = 2.5; 95% CI: 1.6–3.8), inadequate sanitation (aOR = 4.0; 95% CI: 1.9–8.1), behavior (aOR = 2.2; 95% CI: 1.4–) and history of infection (aOR = 3.2; 95% CI: 1.5–) were significant independent predictors. The Hosmer-Lemeshow test showed that the model was good ($p > 0.05$).

Conclusion: The prediction model can be used for the early identification of the risk of stunting. Intervention priority on WASH and prevention of infection is recommended for accelerating stunting reduction in the Regency of Tulang Bawang.

INTRODUCTION

Stunting is a disturbance of linear growth in toddlers that reflects chronic malnutrition and has become a major health problem in global communities. According to a Food and Agriculture Organization (FAO) report, the total world population experiencing a lack of nutrition increased sharply from 650.3 million in 2019 to 768 million in 2020, with Asia recording the highest number of cases (418 million) (1,2,3). The World Health Organization (WHO) estimates that a lack of nutrition causes 3.1 million child deaths every year. Globally, one-third of toddlers experience stunting, wasting, or overweight (4,5,6). The global prevalence of stunting in 2022 is projected to reach 22.3% or 148.1 million children under five, especially in Asia

(52%) and Africa (43%). Southeast Asia has a prevalence of 30.5%, and Indonesia has the second highest prevalence after Timor Leste (3,8).

The impact of stunting is a term for short and long, covering disturbance development in the brain, decline in intelligence, obstacles to physical growth, disorders in metabolism, as well as improvement in the risk of disease such as diabetes, heart disease, and stroke at the age of adults (9,10,11,12). The causes of stunting are: multidimensional, not only influenced by intake nutrition mother and child, but also factors environment like access to clean water limited, sanitation bad hygiene low, infection repetitive (specifically diarrhea), and condition House No feasible (8,13,14,15,16).

The Water, Sanitation, and Hygiene (WASH) program has proven effective in lowering the prevalence of stunting through prevention, infection, and repair of absorption nutrition. Inadequate sanitation causes Environmental Enteric Dysfunction (EED), which is disruptive absorption of substance nutrition, while access to clean water and good hygiene can lower risk up to 29% (17,18,19,20,21,22,23). Studies in various countries confirm a significant connection between diarrhea as a repetitive consequence of fecal-oral contamination with small intestine damage and stunting (8,24,25).

In Indonesia, the prevalence of stunting remains high despite significant economic progress, with the figure being 19.8% in 2024 based on SSGI/Indonesian Nutritional Status Survey (exceeding the national target) (2,26,27,28). Various local studies confirm the role of inadequate sanitation, toilets without septic tanks, careless disposal of rubbish, and infection as a main risk factor (29,30,31,32,33). The Community-Based Total Sanitation Strategy (STBM) has been implemented; however, access to clean water (71.06%) and sanitation house ladders is still low (64.73 %) based on RISKEDAS 2018 (34). Lampung Province shows a trend fluctuating with a prevalence of 15.9% in 2024, exceeding the target of Presidential Decree 72/2021 (35,12).

Although many studies have identified risk factors for stunting through bivariate analysis at the national and district levels, a study that specifically builds a predictive multivariate model using primary data as well as entering complete WASH variables, home conditions, and the incidence of infection in toddlers in the Regency of Tulang Bawang, Lampung Province, is still very limited. This research aims to contribute to the advancement of knowledge by developing a predictive model of stunting incidents in toddlers aged 0–59 months in the Regency of Tulang Bawang in 2024, so it can support the compilation of interventions with higher priority and appropriate targets based on evidence (36,37,38,39,13).

MATERIAL AND METHODS

Written method with a length of 15–20% of the long manuscript and contains (a) draft research, (b) techniques for data collection and sources, and (c) methods for data analysis.

Design Study

This observational study had a cross-sectional design for building a predictive model of stunting in toddlers aged 0–59 months in the Regency of Tulang Bawang in 2024. Approach analysis multivariate regression logistics used for identifying predictors independent from the WASH variable (access to drinking water), safe and sanitary proper behavior (washing hands), the condition of the house (waste and rubbish management), and the history of infection in toddlers. The analysis is performed in a way that gradually starts from candidate selection and model beginning until testing interaction to obtain the final model.

Location and Time of Research

The study was carried out throughout the Regency area of Tulang Bawang, Lampung Province, which is located at 4°05'–4°35' South Latitude and 105°10'–105°45' East Longitude with an area of 3,466.32 km², divided into 15 sub-districts and 147 villages/wards. The majority of residents settled in the low plains along the dangerous Tulang Bawang River flood, so that many houses still use toilet plungers (2,351 houses) and do not have their own toilets (2,490 houses). This condition makes the area highly representative of the relationship between WASH and stunting. Primary data collection will be ongoing for the full six months (August 2024–February 2025). Data processing and report writing will be conducted from March to September 2025.

Population, Sample Size, and Sampling Techniques

The target population is all toddlers aged 0–59 months who were recorded as stunted in the Electronic Community-Based Nutrition Recording and Reporting (e-PPGBM) application of the Regency Tulang Bawang in 2024; as many as 1,287

toddlers of a total of 21,845 toddlers measured height according to age (TB/U). Based on the minimum sample calculation, 204 samples were obtained. The researcher then used a 1:1 ratio so that the number of samples in cases and controls each amounted to 204, resulting in a total of 408 samples. The sampling technique used was *multistage-based*, with high, medium, and low prevalence. The large sample was calculated using the formula for the hypothesis test of the sample difference between two proportions.

Data Collection

Data were collected through two complementary channels. To ensure completeness and accuracy, Channel First is secondary data from three official sources: the e-PPGBM 2024 application, which provides NIK, child's name, date of birth, z-score, and village name; Channel The second is direct observation carried out through a questionnaire that records the type of toilet, drinking water source, hand-washing behavior, waste management (trash), and house status (slums and houses). No worthy inhabitants and a history of infection diarrhea in toddlers. Questionnaire related to access to clean, safe water and access to sanitation worthy of use: 2019 SUSENAS questionnaire on health and housing module.

Data analysis

Data were analyzed using SPSS version 26.0. The dependent variable was stunting status (stunting = 0, not stunting = 1). Independent variables were categorized as binary or dichotomous in accordance with national standards (drinking water safe/not safe, sanitary/not sanitary, hand washing according to standards/not, waste management according to standards/not, rubbish management according to standards/not, and history of infection present/absent). Bivariate analysis was performed using the chi-square test with a significance level of $p < 0.05$ for the selection of candidate variables. Multivariate binary logistic regression analysis was performed in a step-by-step manner: (a) modeling all candidate variables; (b) backward elimination up to variables with significant $p < 0.05$; (c) testing interaction between significant variables; and (d) evaluation of final model fit, Nagelkerke R Square, and classification prediction. Odds ratios (OR) and adjusted odds ratios (aOR) with 95% confidence intervals (CI) are reported. The strength of the connection was measured.

Ethical Approval

All procedures were performed in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained. verbally from parents / guardians toddler before home data collection stairs and verification field .

RESULTS

Characteristics Subject Study

This study involved 408 respondents in the group of stunted and non-stunted toddlers aged 0–59 months in the Regency of Tulang Bawang. Most subjects originated from the house ladder with access to drinking water. No safe (37.7%), sanitation No decent (12%) behavior, and wash hands. No, according to standards (76.3%), management waste No, according to standards (94.6%), and management waste. No, according to standards (93.9%), 20.3% of toddlers own a history of infection (especially diarrhea and acute respiratory infections (ARI) in the last two months (Table 1).

Table I: Characteristics Subject Research

Variables	n	%
Stunting Status		
Stunting	204	50,0
Normal	204	50,0
Safe Drinking Water		
Safe	254	62,3
Not safe	154	37,7
Access to Proper Sanitation		
Worthy	359	88,6
Not feasible	49	12,0
Behavior Washing hands		

According to standards	98	24 , 0
Not up to standard	310	76 , 0
Management Waste		
According to standards	22	5 , 4
Not up to standard	386	94 , 6
Management Rubbish		
According to standards	25	6 , 1
Not up to standard	383	93 , 9
Infection History		
Not exposed	325	79.7
Exposed	83	20.3

Analysis Bivariate

The chi-square test showed a significant connection ($p < 0.05$) between stunting incidence and several independent variables. access to unsafe drinking water ($p < 0.001$; OR = 2.5; 95% CI: 1.6–3.8), access to inadequate sanitation ($p < 0.001$; OR = 2.48; 95% CI: 2.05–3.00), handwashing behavior ($p = 0.002$; OR = 2.2; 95% CI: 1.4–3.6), and history of infection ($p < 0.001$; OR = 3.2; 95% CI: 1.9–5.5). All variables fulfilled the $p < 0.25$ criteria for entry into the multivariate analysis (Table 2).

Table II. Relationships Independent with Stunting Incidence

Variables	Stunting (n)	Not Stunting (n)	OR	95% CI	p-value
Safe Drinking Water					
Safe	105	149	1.00	Reference	<0.001
Not safe	9 9	5 5	2.5	1, 6 – 3 , 8	
Access to Proper Sanitation					
Worthy	38	1 1	1.00	Reference	<0.001
Not feasible	1 6 6	193	4 , 0	2.0–3.0	
Behavior Washing hands					
Correct	34	64	1.00	Reference	0.002
Not true	170	140	2 , 2	1, 4 – 3 , 6	
Management Waste Methods					
Correct	8	14	1.00	Reference	0.27 3
Not true	1 96	190	1.78	0 , 7 – 4 , 4	
Management Rubbish					
Correct	195	1 88	1.00	Reference	0, 216
Not true	9	16	1, 8	0.7 – 4.2	
Infection History					
Not exposed	144	181	1.00	Reference	<0.001
Exposed	60	23	3.2	1 , 9 – 5 , 5	

Analysis Multivariate

Modeling regression binary logistics is performed gradually. In stage I (modelling all candidate variables), the significant variable covers all independent variables, namely access to unsafe drinking water, inadequate sanitary, handwashing behavior, waste management methods, rubbish management methods and history of infection. Stage II (backward elimination) showed that the OR change did not exceed 10% for the main variables. Phase III confirmed no significant interactions ($p > 0.05$). The final model included four independent significant variables: access to unsafe drinking water (aOR = 2.55; 95% CI: 1.64–3.98; $P = 0.001$), inadequate sanitation (aOR = 3.87; 95% CI: 1.82–8.22; $p < 0.001$), handwashing behavior (aOR = 2.9; 95% CI: 1.7–4.9; $P < 0.001$), and history of infection (aOR = 2.8; 95% CI: 1.6–5.1; $P < 0.001$). Nagelkerke R Square value = 0.214 (explains 21.4% variation), which means variables freely and simultaneously contribute a limited 21% toward the dependent variable, while 79% is influenced by other variables.

Table III: Analysis Multivariate Final Model of Stunting Incidence in Toddlers in the Regency Tulang Bawang

Variables	OR	95% CI	p-value
Unsafe drinking water	2.55	1.64 – 3.98	0.002
Inadequate Sanitation	3,87	1,82–8,22	<0.001
Handwashing behavior	2,94	1.74 – 4.98	<0.001
History of infection	2,89	1.63 – 5.12	<0.001

This result shows that inadequate sanitation is the strongest predictor (aOR = 3.87), followed by access to drinking water, handwashing behavior, and history of infection. Other variables, such as waste and garbage management, had no significant effect after controlling for confounding factors.

DISCUSSION

This study succeeded in developing predictive models for stunting in toddlers in the Regency of Tulang Bawang, with the identification of four independent main predictors: inadequate sanitation, handwashing behavior, history of infection, and unsafe drinking water access. This model not only confirms the role of dominant environmental factors and infection in the pathogenesis of stunting but also provides a contextual outlook for the area in Tulang Bawang, where geographical conditions worsen the transmission of pathogens. The following discussion is based on the final model sub-variables, including biological mechanisms, comparisons with other studies, and local implications.

Inadequate Sanitation as Predictor The strongest

Inadequate sanitation variables, including using a toilet without a waste disposal system or indiscriminate defecation behavior, appeared as independent predictors with the highest adjusted odds ratio (aOR of 3.87 (95% CI: 1.82–8.22; $P < 0.001$). This means that toddlers at home on a ladder with poor sanitation have their own risk of stunting, which is almost threefold. Mechanism mainly is improvement exposure pathogen fecal matter that causes infection chronic and EED, where the small intestine experience changes histopathological like thickening walls and settlements function absorption (17,18,19). In Tulang Bawang, where 2,490 houses still lack toilets, floods often pollute wells and rivers, worsening contamination (30,31).

This is in harmony with a cross-sectional study in Indonesia, which found a similar OR (2.48 in bivariate) between toilet unworthiness and stunting (29,22). However, this is different from research in India, which shows a strong interaction between sanitation and economic status (24). This model shows sanitation independent of other variables, highlighting its dominant role in rural areas of Lampung, where STBM access, which is new, has reached 55.85% (34). In general, deep sanitation bad not only triggers diarrhea but also chronic micronutrient deficiencies, which worsen stunting through cycle malabsorption (21,40) Policy implications: Expansion of the healthy toilet program and ODF declaration in hotspot districts such as Menggala and Banjar Margo are needed to reduce the burden of disease.

History of Infection in Toddlers

The infection history variable appeared as an independent predictor with the highest adjusted odds ratio (aOR) of 2.89 (95% CI: 1.63–5.12; $p < 0.001$). Toddlers with a history of infection have more opportunities for double experiencing stunting compared to those who do not, after controlling for other WASH variables. The biological mechanism involves a malignant cycle between infection and malnutrition: repetitive infection causes improvement, which needs energy, metabolic disorders, absorption of nutrition in the intestines, and weakening of the immune system, which ultimately hinders linear growth (9,10,11). In general, specific chronic diarrhea triggers Environmental Enteric Dysfunction (EED), a condition in which the intestinal mucosa experiences chronic inflammation, shortened intestinal villi, and increased permeability so that substances such as protein, iron, and zinc are not optimally absorbed (12,13,14).

In Regency Tulang Bawang, most of whose territory is low plains along the Tulang Bawang River and is vulnerable to seasonal flooding, fecal-oral infections such as diarrhea are more easily spread through contaminated water and poor sanitation (15,16). This is in line with a study in five Indonesian provinces that found repetitive infection to be the main reason for stunting in the coastal region with low WASH access (10,17). However, in contrast to studies in India that emphasize diarrhea as a single mediator (18,19), this study shows that infection is still independent, although WASH controlled, indicating the role of ISPA as an additional factor in the tropical climate of Lampung. This implies that preventing infection through complete immunization, strengthening surveillance at Posyandu, and integration with the STBM program must become a priority to break the cycle. This.

Handwashing Behavior

Handwashing behavior emerged as an independent predictor with the highest adjusted odds ratio (aOR) of 2.94 (95% CI: 1.74–4.98; $p < 0.001$). Families that did not implement standard handwashing behavior had more than twice the chance of experiencing stunting compared to families that implemented standard handwashing behavior, after controlling for other WASH variables. Maintaining personal hygiene is the first step to avoid the possibility of infection. Forms of maintaining personal hygiene include the habit of washing hands with running water and using soap (20).

Research conducted on toddlers aged 0-23 months in India showed that mothers' habit of washing their hands with soap before eating and after defecation can reduce the risk of stunting by 15% (21). Efforts to prevent stunting by promoting handwashing behavior are recommended in several studies because this behavior can break the chain of travel of germs that cause diarrheal infections into the child's body (21).

Unsafe Drinking Water Access

Unsafe drinking water access appears as an independent predictor with aOR = 2.55 (95% CI: 1.64–3.98; $p = 0.002$), indicating a risk of stunting 2.55 times higher in toddlers with polluted water sources. Biological mechanisms involving contamination by bacteria such as *E. coli*, which causes subclinical diarrhea, disturbing gut microbiota, and reduced absorption of essential nutrients such as vitamin A and zinc (23,24,25). In Tulang Bawang, where most of the House ladder depends on shallow and vulnerable wells, drinking water is often polluted with stool, worsening the cycle of infection and stunting (26,27).

This result is in line with the 2018 RISKEDAS survey, which showed that access to clean water nationally is only 71.06%, with a similar OR in the study province (28,29). Different from findings in Africa, where safe water is not available, sanitation is more dominant (30), and research This place drinks water as a predictor lastly, maybe because interaction with floods has more local influence on sanitation. In-depth, water is polluted, causing infections and chronic deficiencies through heavy metal poisoning in groundwater (20,31). Implications: Investment in infrastructure, such as home water filters, ladders, or PDAM expansion in village slums, is necessary to increase safe access to water up to 100%.

Variables Not Included in the Final Model

Waste management and rubbish management insignificant waste are bivariate ($p > 0.05$) and multivariate. This shows the confounding variable effect of waste management and rubbish management possibilities mediated by sanitation and drinking water in the fecal-oral chain (32,33). For example, substandard handwashing behavior (76% prevalence) is often correlated with polluted water, so the effect was captured by water access (34,35). Conditions at home, even though related to stunting in urban studies (14,36), perhaps overlap with WASH in the rural context of Tulang Bawang, where the slum house (28.5%) is often identical to bad sanitation.

This differs from an Indian study Sarma et al. (19) highlighted context-specific information: in Tulang Bawang, rubbish management is not true (70.2%) and pollutes groundwater, but the effect is not independent after control. This implies that holistic WASH interventions are more effective than a single target, such as integrated CTPS promotion with water supply (37,38).

Model Qualities , Limitations , and Implications

The model showed good quality: Nagelkerke R Square = 0.214 (explains 21.4% variation). This is taller than a similar model in Malang (39), but there are still unexplained variations of nutritional, genetic, or maternal factors (40,41,42). Similar predictive modeling studies have identified multiple clinical and patient-related factors influencing treatment outcomes, emphasizing the importance of comprehensive risk assessment (43). Similar determinant and spatial modeling studies have reported that disease outcomes and transmission dynamics are influenced by clinical, social, environmental, and demographic factors, highlighting the importance of comprehensive predictive models and targeted interventions (43,44,45). Limitations: cross-sectional study causality, secondary data potential reporting bias (46), and not including economic variables. Strength: large sample (408) and the latest 2024 data.

CONCLUSION

This study successfully built a predictive model for stunting in toddlers aged 0–59 months in the Regency of Tulang Bawang, Lampung Province, in 2024. The final multivariate model identified four independent significant predictors: unsafe drinking water access (aOR = 2.55), inadequate sanitation (aOR = 3.87), handwashing behavior (aOR = 2.94), and history of infection (aOR = 2.89). These findings confirm that water, sanitation, and hygiene (WASH) factors and infection play a dominant role in stunting incidents in vulnerable areas such as flood-prone Tulang Bawang, after control variables such as waste and garbage management. The model exhibited good compatibility and accurate prediction. This can be utilized. For screening risk early based on routine e-PPGBM data and Family Data Collection, so that support intervention right priorities target in effort acceleration decline stunting prevalence according to national targets.

ACKNOWLEDGEMENTS

The author thanks the Directorate General of Higher Education, Research, and Technology of the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia for funding this study through the Doctoral Dissertation Study Scheme 2024–2025. Accept love is also conveyed to the District Health Office of Tulang Bawang, the Posyandu cadres, and all respondents who willingly participated in the data collection. Support from the Doctoral Study Program Knowledge Environment Postgraduate Program of the University of Lampung also expedited the implementation study.

REFERENCES

- [1] UNICEF, WHO, World Bank. Levels and trends in child malnutrition: Joint child malnutrition estimates 2021 edition. New York: UNICEF; 2021. Available from: <https://www.unicef.org>
- [2] Fikawati S, Syafiq A. Gizi anak dan remaja. Jakarta: RajaGrafindo Persada; 2017.
- [3] Dewey KG, Begum K. Long-term consequences of stunting. *Matern Child Nutr*. 2011;7(Suppl 3):5–18. doi:10.1111/j.1740-8709.2011.00349.x
- [4] Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and child undernutrition: Consequences for adult health and human capital. *Lancet*. 2008;371(9609):340–57. doi:10.1016/S0140-6736(07)61692-4
- [5] Hoddinott J, Alderman H, Behrman JR, Haddad L, Horton S. Adult consequences of growth failure in early childhood. *Am J Clin Nutr*. 2013;98(5):1170–8. doi:10.3945/ajcn.113.064584
- [6] Ministry of Villages, Development of Disadvantaged Regions and Transmigration. Village pocket book on stunting management. Jakarta: Ministry of Villages; 2017.
- [7] Picauly I, Toy SM. Analisis determinan dan pengaruh stunting terhadap prestasi belajar anak sekolah di Kupang dan Sumba Timur. *Media Gizi Indones*. 2013;8(1):55–62.

- [8] Tobing ML, Siregar FA, Nurmaini. Kabupaten/kota prioritas intervensi stunting. *PREPOTIF J Kesehat Masy*. 2021;13(1):238–44.
- [9] Budge S, Parker AH, Hutchings PT, Garbutt C. Environmental enteric dysfunction and child stunting. *Nutr Rev*. 2019;77(4):240–53. doi:10.1093/nutrit/nuy068
- [10] Vilcins D, Sly PD, Jagals P. Environmental risk factors associated with child stunting. *Ann Glob Health*. 2018;84(4):551–62. doi:10.29024/aogh.2361
- [11] Krisnana I, Widiani NM, Sulistiawati S. Prenatal and postnatal factors related to stunting. *Sri Lanka J Child Health*. 2020;49(3):223–9. doi:10.4038/sljch.v49i3.9138
- [12] Rah JH, Sukotjo S, Badgaiyan N, Cronin AA, Torlesse H. Household sanitation and personal hygiene practices are associated with child stunting. *BMJ Open*. 2015;5:e005180. doi:10.1136/bmjopen-2014-005180
- [13] Rah JH, Cronin AA, Badgaiyan B, Aguayo VM, Coates S, Ahmed S. Improved sanitation associated with reduced stunting. *Matern Child Nutr*. 2020;16(S2):e12741. doi:10.1111/mcn.12741
- [14] Lunn PG. Impact of infection and nutrition on gut function. *Proc Nutr Soc*. 2000;59:147–54. doi:10.1017/S0029665100000173
- [15] Watanabe K, Petri WA. Environmental enteropathy. *EBioMedicine*. 2016;10:25–32. doi:10.1016/j.ebiom.2016.07.030
- [16] Action Against Hunger. Universal access to WASH. New York; 2021.
- [17] Torlesse H, Cronin AA, Sebayang SK, Nandy R. Determinants of stunting in Indonesian children. *BMC Public Health*. 2016;16:669. doi:10.1186/s12889-016-3339-8
- [18] USAID. Water and development strategy implementation brief. Washington DC: USAID; 2016.
- [19] Gupta AK, Santhya KG. Childhood stunting in India. *PLoS One*. 2020;15:e0237661. doi:10.1371/journal.pone.0237661
- [20] Sarma H, Khan JR, Asaduzzaman M, Uddin F, Tarannum S, Hasan MM. Factors influencing stunting. *Food Nutr Bull*. 2017;38(3):291–301. doi:10.1177/0379572117710103
- [21] UNICEF. State of the world's children 2019. New York: UNICEF; 2019.
- [22] Ramayulis R. Stop stunting dengan konseling gizi. Jakarta: Penebar Plus; 2018.
- [23] Ministry of Health Indonesia. Basic Health Research (Riskesdas). Jakarta: MoH; 2018.
- [24] World Bank. Aiming high: Indonesia's ambition to reduce stunting. Washington DC: World Bank; 2018.
- [25] Adiyanti M. Sanitasi lingkungan sebagai faktor risiko stunting. *J Kesehat Masy*. 2014;9(1):71–7.
- [26] Zairinayati Z, Purnama R. Sanitasi lingkungan dengan stunting. *Babul Ilmi J Mult Sci Kesehat*. 2019;11(1):34–43.
- [27] Directorate General of Public Health. Waste management guideline. Jakarta: MoH; 2016.
- [28] Solin AR, Hasanah O, Nurchayati S. Penyakit infeksi dan stunting. *JOM FKp*. 2019;6(1):65–71.
- [29] Marlinae. Dasar kesehatan lingkungan. Yogyakarta: Deepublish; 2021.
- [30] Ministry of Health Indonesia. STBM guideline. Jakarta: MoH; 2012.
- [31] BPOM Indonesia. Hygiene sanitation guideline. Jakarta: BPOM; 2013.
- [32] Hastono SP. Analisis data kesehatan. Jakarta: RajaGrafindo; 2016.
- [33] Ministry of Villages. Stunting management guideline. Jakarta; 2017.
- [34] Lapenangga F, Ginting KB. Logistic regression stunting. *J Health*. 2021;3(1):28–37.
- [35] Pramodyo H, Fitriani R, Kurniawan R. Spatial model stunting. *Medika Pearls*. 2020;20(2):98–103.

- [36] Putra PAB, Suariyani NLP. GIS mapping stunting. *Arch Community Health*. 2021;8(1):72–9.
- [37] Eryando T. Spatial analysis health data. *Kesmas*. 2022;17(3):165–8. doi:10.21109/kesmas.v17i3.6196
- [38] Hasandi LA, Fitria L, Wahyudi A. Waste management Indonesia. *Kapuas Geogr J*. 2019;11:29–38.
- [39] Hien NN, Hoa NN. Malnutrition Vietnam. *Pak J Nutr*. 2009;8:958–64. doi:10.3923/pjn.2009.958.964
- [40] El Taguri A, Betimal I, Mahmud SM, Ahmed AM, Goulet O, Galan P, et al. Risk factors stunting Libya. *East Mediterr Health J*. 2008;14(3):633–41.
- [41] Rasool Hassan BA. Importance personal hygiene. *Pharm Anal Acta*. 2012;3:e126.
- [42] Ministry of Health Indonesia. *Riskesdas report*. Jakarta: MoH; 2018.
- [43] Wardani DWSR, Sumarmi S, Mubasyiroh R, Notobroto HB. Determinants delayed sputum conversion. *Indian J Community Med*. 2018;43(3):204–9. doi:10.4103/ijcm.IJCM_241_17
- [44] Wardani DWSR, Sumarmi S, Mubasyiroh R, Notobroto HB. Determinants sputum conversion TB. *Indian J Community Med*. 2019;44(1):53–7. doi:10.4103/ijcm.IJCM_120_18
- [45] Wardani DWSR, Wahono EP. Spatio-temporal TB clusters. *Indian J Community Med*. 2020;45(1):43–7. doi:10.4103/ijcm.IJCM_182_19
- [46] Leroy JL, Frongillo EA. What does stunting mean. *Adv Nutr*. 2019;10(2):196–204. doi:10.1093/advances/nmy101
- [47] Puspitasari Y, Wardani DWSR, Darmawan A, Tugiyono. Geospatial analysis of stunting incidents in toddlers in Tulang Bawang District Lampung Province. *TPM- Testing, Psychometrics, Methodology, in Applied* 2025; 32(4).