

Socio-Environmental Determinants of Dengue Fever in South Sulawesi, Indonesia: Integrating Household Conditions, WASH, and 3M Prevention Practices to Support the Sustainable Development Goals

Syamsuar Manyullei

`syamsuar.m@unhas.ac.id`

Universitas Hasanuddin

Muhammad Aidil Fitrah

Universitas Mulawarman

Uyuun Wiji Sasmita

Makassar Health Quarantine Center

Grace Glory Girikallo

Universitas Hasanuddin

Rudi Hendro Purtanto

National Research and Innovation Agency

Research Article

Keywords: Dengue fever, Indonesian Health Survey, WASH, 3M Plus, Household Vulnerability, South Sulawesi

Posted Date: August 13th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10139283/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.
[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Dengue fever remains a persistent public health challenge in Indonesia, particularly in areas with rapid urbanization and heterogeneous household environmental conditions. In South Sulawesi, dengue transmission may be influenced by housing quality, water, sanitation and hygiene conditions, and household mosquito breeding-site control. This study aimed to identify household environmental and behavioural factors associated with dengue fever in South Sulawesi using data from the 2023 Indonesian Health Survey.

Methods

This cross-sectional analytical study used secondary data from respondents residing in South Sulawesi. Dengue fever was defined as self-reported physician-diagnosed dengue within the previous year. Independent variables included sewage system, house roof, ceiling, floor, wall, and dengue preventive behaviour. Descriptive statistics were used to summarize respondent and household characteristics. Bivariate analysis was performed using chi-square tests and crude odds ratios with 95% confidence intervals. Significant variables were further examined using multivariable logistic regression with the backward likelihood ratio method.

Results

Among 46,514 respondents, 308 dengue fever cases were reported. The weighted dengue prevalence in South Sulawesi was 0.77% (95% CI: 0.63–0.94), higher than the national estimate of 0.64% (95% CI: 0.59–0.70). Most households had sewage systems that did not meet standards (92.0%) and ceilings that did not meet standards (84.2%). Bivariate analysis showed that substandard roof condition was significantly associated with dengue fever (OR = 2.02; 95% CI: 1.28–3.20; $p = 0.003$). Floor condition and preventive behaviour were also significantly associated. In the final model, roof condition and preventive behaviour remained significant predictors.

Conclusions

Dengue fever in South Sulawesi is associated with household environmental and behavioural factors. These findings support integrated dengue control strategies combining housing improvement, WASH strengthening, community-based 3M Plus practices, and household-level vector surveillance.

Introduction

Dengue Hemorrhagic Fever (DHF) is a disease caused by dengue virus infection transmitted through the bite of infected *Aedes* mosquitoes, particularly *Aedes aegypti* and *Aedes albopictus*. This condition is generally characterised by sudden high fever lasting two to seven days and may progress to severe dengue in some cases. Dengue fever remains a major public health issue in tropical and subtropical regions, especially in urban and semi-urban settings where vector breeding, human mobility, water storage, and household environmental conditions facilitate transmission [1, 2].

In recent decades, dengue fever has increased substantially worldwide. The number of dengue cases reported to the World Health Organization rose from 505,430 cases in 2000 to 14.6 million cases in 2024. In 2024, more than 14.6 million cases and over 12,000 dengue-related deaths were reported globally, while from January to July 2025, more than 4 million cases and over 3,000 deaths were reported from 97 countries [2]. This increasing burden demonstrates that dengue is not only a local or national problem, but also a global public health concern requiring integrated prevention and control strategies. Indonesia is one of the countries in Southeast Asia with a substantial dengue burden. In 2023, Indonesia reported 114,720 dengue cases, lower than 143,266 cases in the previous year; however, dengue remains endemic in many provinces, including South Sulawesi [3]. South Sulawesi is an important province for dengue prevention because it combines a dense urban centre, coastal and peri-urban settlements, and heterogeneous household environmental conditions. According to the 2023 Indonesian Health Survey South Sulawesi had a weighted dengue prevalence of 0.77% (95% CI: 0.63–0.94), which was higher than the national estimate [4].

The high occurrence of dengue fever is closely related to environmental sanitation, household water management, housing quality, and community behaviours that support or prevent the breeding of *Aedes* mosquitoes. This makes dengue a recurring health problem in endemic areas, especially where household environmental management and mosquito breeding-site control are not consistently implemented [5]. From an environmental health perspective, dengue transmission reflects the interaction between host, agent, vector, and environment. Houses that do not meet healthy housing standards may increase household vulnerability through poor ventilation, inadequate drainage, moisture, unmanaged water containers, poor sanitation, and suboptimal waste management. Physically, a healthy house should have dry and cleanable floors and walls, adequate ventilation, sufficient lighting, and environmental conditions that reduce disease transmission risks [6, 7].

Dengue prevention is also closely aligned with the Sustainable Development Goals (SDGs). SDG 3 aims to ensure healthy lives and promote well-being for all, including the prevention and control of communicable diseases and health risks related to unsafe water, sanitation, and hygiene. SDG 6 emphasizes universal and equitable access to safe drinking water, adequate sanitation, hygiene, and improved wastewater management. Meanwhile, SDG 11 promotes safe, resilient, inclusive, and sustainable cities and human settlements, including access to adequate housing and basic services [8–10]. Therefore, dengue prevention should not be understood only as a vector-control or clinical issue, but also as part of a broader sustainable development agenda involving housing improvement, WASH strengthening, environmental management, and community participation.

The 2023 Indonesian Health Survey provides an important evidence base for this integrated perspective. The SKI 2023 environmental health component includes indicators related to drinking water, sanitation, wastewater disposal, waste management, basic hygiene, livable housing, and mosquito breeding-site control. These indicators are relevant to SDG 6, SDG 11, and household-level dengue prevention. In South Sulawesi, contextual SKI indicators showed that 88.9% of households had basic drinking-water access, 5.9% had safe sanitation, 77.4% had basic hygiene access, and 71.7% met livable housing criteria. However, dengue prevention practices remained limited, with only 13.3% of households reporting complete 3M practices and 5.8% reporting 3M Plus practices, while 80.9% reported neither [4]. These findings indicate that the dengue prevention gap is not only epidemiological, but also socio-environmental and behavioural.

However, previous studies have often focused on general household hygiene or isolated physical housing components without adequately integrating sociodemographic characteristics, WASH conditions, housing quality, and mosquito breeding-site control practices into a single analytical framework. This creates an important evidence gap, particularly for provinces such as South Sulawesi, where dengue transmission may be shaped by interactions between urbanization, household vulnerability, water and sanitation conditions, and community-based prevention behaviours. A broader socio-environmental vulnerability framework is therefore needed to better understand factors associated with dengue fever and to support evidence-based interventions aligned with the SDGs.

This study specifically analyses dengue fever in South Sulawesi by adopting an integrated socio-environmental framework that combines household structural conditions, sociodemographic characteristics, WASH indicators, and mosquito breeding-site control practices. Unlike previous analyses that primarily focused on selected physical housing components, such as roof, floor, ceiling, wall, and sewage system, this study expands the analytical scope by incorporating broader determinants, including age, sex, education, occupation, place of residence, economic status, drinking-water access, sanitation, hygiene, livable housing, and 3M/3M Plus prevention practices. The integration of these variables is important because dengue transmission is shaped not only by the physical quality of the house, but also by household vulnerability, environmental sanitation, water management, and community participation in eliminating *Aedes* mosquito breeding sites. Using data from the 2023 Indonesian Health Survey, this study aims to identify socio-demographic, WASH, household structural, and behavioural factors associated with dengue fever in South Sulawesi. The findings are expected to strengthen evidence for SDG-oriented dengue control strategies that combine housing improvement, WASH strengthening, and community-based 3M Plus implementation.

Materials and Methods

Study Design and Data Source

This study used secondary data from the 2023 Indonesian Health Survey (SKI) with a cross-sectional analytical design, focusing on dengue fever in South Sulawesi Province, Indonesia. The analysis

examined dengue occurrence within an integrated socio-environmental framework, including socio-demographic factors, household structural conditions, WASH indicators, and mosquito breeding-site control practices. Using SKI 2023 data enabled dengue fever to be contextualized as both a disease outcome and a household-level environmental health issue shaped by social, behavioural, and structural determinants.

Figure 1. Causal Pathway Diagram

Study Population and Sample

The study population consisted of 2023 Indonesian Health Survey respondents residing in South Sulawesi Province. Eligible respondents were individuals with complete information on dengue fever diagnosis, socio-demographic characteristics, household environmental conditions, WASH indicators, and dengue prevention practices. For provincial contextual estimates, this study also used weighted indicators reported in the official SKI 2023 report. In the official SKI 2023 report, South Sulawesi had a weighted dengue prevalence of 0.77% with a 95% confidence interval of 0.63–0.94 and a weighted population estimate of 29,481.

Dependent Variable

The dependent variable was dengue fever occurrence. In 2023 Indonesian Health Survey dengue fever was defined based on self-reported physician diagnosis within the previous year. Respondents were classified as having dengue fever if they reported that they had been diagnosed with dengue hemorrhagic fever by a physician during the reference period. Respondents who reported no physician diagnosis of dengue fever within the previous year were categorized as non-cases.

Independent Variables

The independent variables were grouped into four domains: socio-demographic characteristics, WASH indicators, household structural conditions, and dengue prevention practices.

Socio-demographic variables included age, sex, educational attainment, occupation, place of residence, and household economic status. Age may be categorized into relevant age groups based on the 2023 Indonesian Health Survey classification. Sex was categorized as male or female. Education may be grouped into no schooling/primary, secondary, and higher education. Occupation may be categorized based on the SKI occupational classification. Place of residence was classified as urban or rural. Household economic status was classified according to wealth quintiles or economic status categories available in the SKI 2023 dataset.

WASH variables included drinking-water access, sanitation access, hygiene access, wastewater disposal, and household waste management. Drinking-water access was classified according to the

availability of basic or improved drinking-water sources. Sanitation was classified based on access to safe or improved sanitation facilities, including the type and use of household latrine facilities and the disposal of fecal waste. Hygiene access was assessed based on the availability of handwashing facilities with water and soap or other cleansing agents. Wastewater disposal included the main disposal route for wastewater from bathing, washing, and kitchen activities. Household waste management was assessed based on the main method of collecting, storing, or disposing of household waste [21]

Household structural variables included roof, ceiling, floor, wall, and livable housing status. Roof condition was categorized according to the main construction material of the largest roof area. Ceiling condition was categorized based on the dominant ceiling or inner roof material. Floor condition was categorized according to the main floor material of the largest floor area. Wall condition was categorized according to the main wall material. Livable housing status was used as a composite contextual indicator reflecting the overall suitability of housing condition [22].

Dengue prevention practice variables included mosquito breeding-site control and 3M/3M Plus practices. The 3M practices consisted of draining water containers, covering water storage containers, and reusing, recycling, burying, or disposing of used items that may become mosquito breeding sites. The 3M Plus practices included additional protective measures such as using mosquito nets or repellents, installing screens on ventilation or windows, using larvicide where appropriate, and other household actions to prevent mosquito bites and reduce *Aedes* breeding sites. Based on the SKI 2023 classification, households may be categorized as performing complete 3M, performing 3M Plus, or not performing either practice.

Statistical Analysis

Descriptive statistics were used to summarize respondent characteristics, WASH conditions, household structural factors, dengue prevention practices, and dengue fever occurrence. Categorical variables were presented as frequencies and percentages. Where survey weights were available, weighted percentages and 95% confidence intervals were reported to improve representativeness.

Bivariate analysis was conducted to examine associations between dengue fever and each independent variable using chi-square tests and crude odds ratios with 95% confidence intervals. Data are presented in the form of frequencies and percentages based on variable categories, and then bivariate analysis is performed using the Chi-Square test to determine the relationship between independent and dependent variables. Variables that are significantly related ($p < 0.05$) will be followed up with multivariable analysis using logistic regression tests to determine variables with significant effects. All analyses were performed using SPSS 22.0 (IBM Corporation, NY, USA).

Because Indonesian Health Survey 2023 used a complex survey design, analyses should account for sampling weights, clustering, and stratification where the required design variables are available. Model interpretation was conducted cautiously because the cross-sectional design does not establish

temporality or causality. In particular, associations between dengue fever and prevention practices were interpreted with attention to potential reverse causality, as households with previous dengue experience may have adopted 3M or 3M Plus practices after illness occurred.

Results

Table 1. Weighted Dengue Fever Prevalence Based on Indonesian Health Survey 2023

Table 1 Weighted Dengue Fever Prevalence Based on Indonesian Health Survey 2023			
Area	Dengue Prevalence (%)	95% CI	Weighted N
South Sulawesi	0.77	0.63–0.94	29,481
Indonesia	0.64	0.59–0.70	877,531

Table 1 shows the official 2023 Indonesian Health Survey report showed that South Sulawesi had a weighted dengue fever prevalence of 0.77% (95% CI: 0.63–0.94; weighted N = 29,481). This estimate was higher than the national dengue prevalence of 0.64% (95% CI: 0.59–0.70; weighted N = 877,531). This result indicates that dengue remains a relevant provincial public health problem and supports the need for a more complete socio-environmental analysis.

Table 2. National Sociodemographic Pattern of Dengue Prevalance in Indonesia Health Survey

Table 2 National Sociodemographic Pattern of Dengue Prevalance in Indonesia Health Survey		
Sociodemographic Characteristic	Category with Notable Prevalence	Dengue Prevalence (%)
Age Group	5–14 years	0.80
Sex	Male	0.64
	Female	0.65
Education	No schooling	0.77
	Completed senior high school	0.69
Occupation	Schooling	0.80
	Private employee	0.78
Residence	Urban	0.73
	Rural	0.52
Economic Status	Highest quintile	0.88

Table 2 shows the publicly available Indonesian Health Survey 2023 report presents dengue prevalence by sociodemographic characteristics at the national level. Nationally, dengue prevalence was highest among children aged 5–14 years (0.80%) and respondents who were still in school (0.80%). Urban residents had higher dengue prevalence than rural residents (0.73% versus 0.52%), and the highest economic quintile showed higher prevalence than lower and middle quintiles.

Figure 2. Dengue Fever in Indonesia: SKI 2023 National Pattern

Figure 2 shows national pattern of dengue fever prevalence in Indonesia based on SKI 2023. South Sulawesi is highlighted as the study area, with a weighted dengue prevalence of 0.77% (95% CI: 0.63–0.94), higher than the national estimate of 0.64% (95% CI: 0.59–0.70). The figure also shows that dengue prevalence was higher among children aged 5–14 years, urban residents, and the highest wealth quintile.

Table 3. WASH and Household Structural in South Sulawesi Based on Indonesia Health Survey 2023

Table 3 WASH and Household Structural in South Sulawesi Based on Indonesia Health Survey 2023			
Indicator	South Sulawesi (%)	Indonesia (%)	Interpretation
No drinking – water access	0.6	1.2	Lower than national
Non improved drinking – water access	6.5	6.2	Similar to national
Limited drinking – water access	4.1	3.0	Slightly higher than national
Basic drinking – water access	88.9	89.6	Similar to national
Safe sanitation access	5.9	11.5	Lower than national
Safe non – toilet wastewater management	9.6	15.3	Lower than national
Good solid – waste management	33.4	37.8	Lower than national
Basic hygiene access	77.4	78.9	Similar to national
Livable housing	71.7	65.1	Higher than national
Roof clasified as adequate	95.9	87.8	Higher than national
Floor classified as adequate	99.2	97.0	Higher than national
Wall classified as adequate	92.8	98.7	Lower than national

Table 3 shows the profile of South Sulawesi showed a mixed pattern. Basic drinking-water access was high (88.9%), and 71.7% of households met the livable housing criteria. However, safe sanitation access was only 5.9%, safe non-toilet wastewater management was 9.6%, and good solid-waste management

was 33.4%. These indicators suggest that although general access to water and basic housing conditions are relatively favourable, environmental risk pathways for mosquito breeding may persist through inadequate sanitation, wastewater disposal, and solid-waste management.

Figure 3. Selected Contextual Indicators for Dengue Related Environmental Vulnerability in South Sulawesi

Figure 3 shows that although basic water access, basic hygiene, and livable housing were relatively high, safe sanitation, good waste management, and 3M/3M Plus practices remained limited. These gaps indicate the need to strengthen household-level dengue prevention through integrated WASH improvement, environmental management, and community-based mosquito breeding-site control.

Table 4. Frequency Distribution of Variables and DHF Incidence in South Sulawesi 2023

Table 4 Frequency Distribution of Variables and DHF Incidence in South Sulawesi 2023			
Variable	Category	N	Percentage (%)
Dengue Fever Case	Case	308	0.7
	No Case	46,206	99.3
Sewage System	Does Not Meet Standard	42,807	92
	Meets Standard	3,707	8
House Roof	Does Not Meet Standard	1,549	3.3
	Meets Standard	44,965	96.7
House Ceiling	Does Not Meet Standard	39,170	84.2
	Meets Standard	7,344	15.8
House Floor	Does Not Meet Standard	27,644	59.4
	Meets Standard	18,870	40.6
House Wall	Does Not Meet Standard	22,838	49.1
	Meets Standard	23,676	50.9
Preventive Behavior	No	8,813	18.9
	Yes	37,701	81.1

Table 4 shows the frequency distribution of dengue fever incidence, household environmental conditions, and preventive behavior among respondents in South Sulawesi in 2023. Of 46,514 respondents, 308 respondents (0.7%) were reported as dengue fever cases, while the majority, 46,206 respondents (99.3%), were non-cases. Most households had sewage systems that did not meet the

standard (92.0%) and house ceilings that did not meet the standard (84.2%). More than half of respondents also lived in houses with floors that did not meet the standard (59.4%), while house wall conditions were relatively balanced between those that met and did not meet the standard. In contrast, most households had roofs that met the standard (96.7%). Regarding dengue prevention, 37,701 respondents (81.1%) reported practicing preventive behavior, while 8,813 respondents (18.9%) did not. Overall, the table indicates that although preventive behavior was commonly reported, several household environmental conditions, particularly sewage systems, ceilings, and floors, remained suboptimal.

Table 5. Housing Conditions, Preventive Behavior and DHF Incidence in South Sulawesi 2023

Table 5 Housing Conditions, Preventive Behavior and DHF Incidence in South Sulawesi 2023						
Variable	Dengue Fever Cases				OR (95%CI)	p
	Case		No Case			
n	%	n	%			
Sewage System						
Does Not Meet Standard	275	89.3	42,532	92.0	0.72 (0.50–1.35)	0.093
Meets Standard	33	10.7	3,674	8.0		
House Roof						
Does Not Meet Standard	20	6.5	1,529	3.3	2.02 (1.28–3.20)	0.003
Meets Standard	288	93.5	44,677	96.7		
House Ceiling						
Does Not Meet Standard	259	84.1	38,911	84.2	0.99 (0.72–1.34)	1.000
Meets Standard	49	15.9	842	15.8		
House Floor						
Does Not Meet Standard	165	53.6	27,479	59.5	0,78 (0.62–0.98)	0.041
Meets Standard	143	46.4	18,727	40.5		
House Wall						
Does Not Meet Standard	139	45.1	22,699	49.1	0.85 (0.68–1.06)	0.180
Meets Standard	169	54.9	23,507	50.9		
Preventive Behavior						
No	38	12.3	8,775	19.0	0.60 (0.42–0.84)	0.004

Table 5 shows the results of cross-analysis between risk factors and the incidence of dengue hemorrhagic fever (DHF). Several variables, such as roof type (OR = 2.02; 95% CI: 1.28–3.20; p = 0.003), floor type (OR = 0.78; 95% CI: 0.62–0.98; p = 0.041), and preventive behaviour (OR = 0.60; 95% CI: 0.42–0.84; p = 0.004), were significantly associated with DHF incidence. Meanwhile, sewage systems, house ceilings, and house walls did not show a statistically significant association (p > 0.05).

Table 6. Dengue Vector Control and 3M Practices in South Sulawesi Based on Indonesian Health Survey 2023

Table 6 Dengue Vector Control and 3M Practices in South Sulawesi Based on Indonesian Health Survey 2023		
PSN Indicator	South Sulawesi (%)	Indonesia (%)
Larvicide use in water containers	10.5	6.4
Ventilation/window screens	9.8	13.4
Draining large water containers	64.9	59.0
Covering water-storage containers	36.3	35.5
Destroying used items	35.3	40.7
No complete 3M or 3M plus	80.9	79.8
Complete 3M	13.3	12.0
Complete 3M plus	5.8	8.1
Draining > 1 time/week	35.6	27.8
Draining 1 time/week	19.1	22.0
Draining 1–2 times/month	9.8	13.7

Table 6 shows the household mosquito-breeding-site control indicators showed important behavioural gaps. In South Sulawesi, 64.9% of households reported draining large water containers, 36.3% reported covering water-storage containers, and 35.3% reported destroying used items such as cans or tyres. However, the composite 3M indicator was much lower: only 13.3% of households reported complete 3M practices and only 5.8% reported 3M plus practices. Most households (80.9%) reported neither complete 3M nor 3M plus. These findings indicate that partial practices are more common than complete integrated vector-control behaviour.

Table 7. The Effect of Housing Conditions and Preventive Behavior on Dengue Fever Incidence among Respondents in South Sulawesi Province in 2023

Table 7
The Effect of Housing Conditions and Preventive Behavior
on Dengue Fever Incidence among Respondents in South
Sulawesi Province in 2023

Variable	Model 1	Model 2	Model 3
	<i>p</i>	<i>p</i>	<i>p</i>
Preventive Behavior	0,000	0,000	0,000
House Roof	0,213	0,009	0,006
Sewage System	1,167	1,161	-
House Floor	0,763	-	-

Model: Backward LR method. Hosmer and Lemeshow test: $\chi^2 = 1,717$, $p = 0,190$. Nagelkerke $R^2 = 0,156$

Table 7 shows the results of the backward LR logistic regression analysis, which found that in the final model (Model 3), the variables significantly associated with DHF were preventive behaviour ($p = 0.000$) and roof condition ($p = 0.006$). This indicates that respondents with good preventive behaviour are less likely to experience DHF, while substandard roof conditions increase the risk of DHF. Meanwhile, the variables of sewage system and floor condition did not show a significant relationship ($p > 0.05$) and were therefore eliminated from the final model. The Hosmer and Lemeshow test value showed $\chi^2=1.717$ with $p = 0.190$, which means that the model fits the data well. The Nagelkerke R^2 value of 0.156 indicates that the variables in the model are able to explain approximately 15.6% of the variation in DHF cases among respondents.

Figure 4. Logistic Regression Summary of Factors Associated with Dengue Fever in South Sulawesi, 2023.

Figure 4 shows that the backward LR model retained preventive behavior and house roof condition as significant factors, while sewage system and house floor were excluded from the final model.

Discussion

The study, which involved 46,514 respondents spread across South Sulawesi, showed that 308 (0.9%) respondents had been diagnosed by a doctor within one year of experiencing dengue fever (DF). This figure is relatively low when compared to the large population, but it still shows that DF remains a public health issue.

Socio-demographic Factors Associated with Dengue Fever

The inclusion of socio-demographic variables strengthens the interpretation of dengue fever in South Sulawesi because dengue transmission is not only determined by household physical conditions, but

also by population vulnerability, mobility, education, occupation, urban–rural context, and economic status. Age and sex may influence exposure patterns, care-seeking behaviour, and the likelihood of receiving a physician diagnosis. Meanwhile, education may shape knowledge of dengue prevention, recognition of symptoms, and household participation in mosquito breeding-site control. Occupation may also affect daily mobility and exposure to mosquito bites in domestic, workplace, or community settings. Therefore, socio-demographic variables should be treated as important covariates in explaining factors associated with dengue fever rather than as isolated predictors [28, 2].

Urban–rural residence is particularly relevant in South Sulawesi because the province combines dense urban areas, coastal settlements, and peri-urban communities. Dengue has long been associated with urbanization, high population density, and the built environment, but recent evidence also shows that dengue transmission can occur in rural and peri-urban areas where vector habitats, water storage, and mobility patterns overlap. In this context, urban–rural classification may reflect differences in housing density, water availability, waste management, access to health services, and public health surveillance. These differences may influence both true dengue transmission and the probability of being diagnosed by a physician [29, 3].

Economic status is also important because it may indirectly influence dengue exposure through housing quality, access to water and sanitation services, capacity to maintain household environments, and ability to purchase mosquito prevention products. Households with lower economic status may face higher structural vulnerability, including poorer waste management, inadequate drainage, and suboptimal housing materials. Conversely, households with better economic status may have better access to diagnosis and health care, which may increase reported dengue prevalence. Therefore, economic status should be interpreted carefully as both a potential determinant of exposure and a determinant of case detection [30, 2, 4].

WASH Conditions and Household Environmental Vulnerability

The WASH indicators from Indonesian Health Survey 2023 provide important contextual evidence for understanding dengue fever in South Sulawesi. Although basic drinking-water access was relatively high, this indicator should not automatically be interpreted as low dengue risk. In dengue-endemic settings, improved water access may still require household water storage, especially where continuity of water supply is uncertain. Uncovered or poorly maintained water containers can become important breeding sites for *Aedes* mosquitoes. Previous studies have shown that *Aedes* breeding is strongly related to domestic water-holding containers, including buckets, drums, tanks, and other artificial containers commonly found around households [31, 5, 6].

The low proportion of safe sanitation indicates a major environmental health gap. Although *Aedes aegypti* usually breeds in relatively clean stagnant water rather than fecally contaminated environments, poor sanitation often coexists with broader environmental disorder, inadequate drainage, poor

wastewater management, and limited household infrastructure. These conditions may increase the number of water-holding sites and reduce the effectiveness of household-level vector control. Therefore, safe sanitation should be interpreted not merely as a fecal waste indicator, but as part of a broader household environmental vulnerability pathway associated with dengue transmission [1, 32, 7].

Waste management is another critical WASH-related factor. Inadequate waste management can increase the availability of discarded containers, plastic items, cans, tires, and other objects that collect rainwater and serve as *Aedes* breeding habitats. The finding that good waste management remains limited in South Sulawesi suggests that community-level environmental management should be integrated into dengue control. This is consistent with evidence showing that artificial containers and discarded materials are important habitats for immature *Aedes* mosquitoes in domestic and peri-domestic environments [1, 33, 8].

This condition indicates that the community in the research area has a fairly good awareness in building and maintaining household sanitation systems, especially in the management of domestic liquid waste. Closed SPAL functions to prevent environmental pollution, reduce unpleasant odors, and minimize the risk of direct contact between humans and waste [41].

Basic hygiene access was relatively higher than safe sanitation and waste management, suggesting that many households had handwashing facilities with water and soap. While hygiene access is not directly equivalent to dengue prevention, it reflects household capacity to maintain basic environmental health practices. In the context of dengue, basic hygiene may support broader clean-household behaviour, but it cannot replace specific mosquito breeding-site control. Therefore, hygiene indicators should be interpreted together with 3M and 3M Plus practices to better understand whether general cleanliness is translated into dengue-specific preventive behaviour [1, 34].

Livable housing is an important contextual indicator because dengue transmission is strongly related to the household and peri-household environment. Housing conditions may influence indoor resting sites, ventilation, moisture, water accumulation, and the presence of potential breeding sites around the house. Previous evidence suggests that structural housing improvement and domestic vector control interventions can contribute to reducing *Aedes*-related disease risk, although the effectiveness depends on the type of intervention and the level of community implementation. Therefore, livable housing should be discussed as part of household structural resilience against dengue rather than only as a general housing quality indicator [18, 23].

House Conditions Related to Dengue Fever Incidents

The results of the analysis of several aspects of housing conditions indicate that two variables have a significant relationship with the incidence of dengue hemorrhagic fever: the roof and floor of the house. The condition of the roof was found to be significantly associated with the incidence of DHF (OR = 2.02; $p = 0.003$). Furthermore, the results of the logistic regression analysis confirmed that this variable

remained significantly influential in the final model ($p = 0.006$), indicating an independent contribution of roof condition to the risk of DHF after controlling for other variables.

The results of these findings show that respondents living in houses with substandard roofs have more than twice the risk compared to those with standard roofs. In this study, house roofs are considered standard if they use permanent building materials such as concrete, asphalt, clay, tiles, asbestos, or zinc. Conversely, roofs that use non-permanent materials such as bamboo, wood, shingles, straw, palm fiber, leaves, or thatch are categorized as unqualified. Roofs made of non-permanent materials are generally more prone to damage, have gaps, and may not have an optimal slope, thereby increasing the likelihood of rainwater accumulation. This is consistent with the principles of vector ecology, in which the presence of natural or artificial water reservoirs is a major determinant in the mosquito life cycle [24, 35].

Rinawan's (2015) research in Bandung analyzed roof type classification using high-resolution satellite imagery. The study found that houses with less sloping roofs were more often associated with dengue fever hotspots than houses with sloping roofs, and large flat roofs were also more risky than smaller flat roofs [17]. This reinforces the finding that roof quality and design play an important role in controlling the environment for dengue fever vectors. Therefore, the physical condition of the house plays an important role in determining how often contact occurs between mosquitoes and humans. Compared to brick walls, bamboo and wood construction for home walls increases the danger of dengue transmission [40].

In addition to the roof of the house, the condition of the house, especially the floor, showed a significant relationship with the incidence of dengue fever ($OR = 0.78$; $p = 0.041$). However, in the multivariate analysis, the floor variable was eliminated from the final model because the p -value was > 0.05 after controlling for other variables, meaning that its contribution was not independent. In this study, house floors were categorized as meeting the requirements if they used permanent materials such as marble, granite, ceramic, parquet, vinyl, carpet, tiles, or terrazzo. Conversely, floors made of non-permanent materials such as wood, boards, red brick cement, bamboo, or soil were categorized as not meeting the requirements. Permanent floors are waterproof and easy to clean, so they do not cause puddles or excessive moisture that can support mosquito breeding. Conversely, non-permanent floors tend to be difficult to clean, porous, and potentially retain moisture, which can contribute to high vector density inside the house [13].

The condition of a house's floor is an important factor in preventing the presence of *Aedes aegypti* larvae. Research by Adolfo (2021) in Colombia reported a significant relationship between the condition of a house's floor and the risk of dengue fever, where non-permanent floors increase the potential for mosquito larvae to be present. Additionally, findings from houses in poor physical condition also support an increased risk of dengue fever [25, 14, 15]. Another study in Kenya reported that houses with dirt floors or non-permanent floors had a higher prevalence of mosquitoes than houses with permanent floors [16]. Thus, although floor type did not emerge as an independent factor in the multivariate model, in practical terms, floor conditions remain relevant as part of household sanitation improvement efforts in dengue prevention.

This study found that other household conditions, such as sewage systems, ceilings, and walls, were not significantly associated with dengue fever cases. Sewage systems are generally not the primary habitat of *Aedes aegypti*. This can be explained because *Aedes aegypti* generally breeds in containers of clear, stagnant water, not in sewage systems, which generally contain dirty water with high organic content, which is preferred by mosquitoes [26]. Meanwhile, the condition of house walls and ceilings is not directly related to the mosquito life cycle, as the primary factor influencing vector density is the presence of breeding sites. This study investigated the behavior of mosquitoes living indoors, including their preference for walls as resting places, and showed that although walls are used as resting places, structural variables such as walls or ceilings are not always significant if environmental factors in the home, such as humidity, ventilation, and room conditions, are more dominant [36]. Thus, these three variables did not contribute significantly to the increased risk of DHF in this study.

PSN, 3M, and 3M Plus Practice

The PSN indicators show an important behavioural gap in dengue prevention in South Sulawesi. Although household environmental risks are present, the proportion of households reporting complete 3M and 3M Plus practices remains limited. This finding indicates that dengue prevention cannot rely only on the availability of water, sanitation, or housing infrastructure; it also requires consistent household and community action to eliminate *Aedes* breeding sites. The 3M approach—draining water containers, covering water storage, and eliminating used items that may collect water—is directly aligned with the biological control of *Aedes* breeding habitats [1, 11].

The low proportion of 3M Plus practices suggests that additional protective measures have not been widely adopted. The “Plus” component is important because dengue prevention requires more than removing breeding sites; it also includes reducing human–mosquito contact through repellents, larvicide where appropriate, window or ventilation screens, mosquito nets, and community clean-up activities. These measures are especially relevant in areas where household water storage, waste accumulation, and housing vulnerability persist. Therefore, increasing 3M Plus implementation should be a central component of household-based dengue control in South Sulawesi [27, 11, 12].

However, the association between preventive practices and dengue fever should be interpreted cautiously in a cross-sectional study. Households with previous dengue experience may become more likely to adopt 3M or 3M Plus practices after illness has occurred. This reverse causality may explain why reported prevention behaviour does not always appear protective in cross-sectional analysis. Therefore, preventive behaviour should be discussed as an associated factor rather than a causal determinant unless longitudinal or intervention data are available [28, 12].

Preventive Behavior Against Dengue Fever

Preventive behavior variables showed a significant association with DHF incidence (OR = 0.60; 95% CI: 0.42–0.84; $p = 0.004$), and multivariate logistic regression analysis showed that preventive behavior remained significant in the final model ($p = 0.000$). Respondents who did not take preventive measures had a higher risk of experiencing DHF compared to respondents who did take preventive measures.

Preventive behavior was a strong independent protective factor, even after controlling for other household condition variables (roof, floor, sewage system, ceiling, and walls).

The findings of this study confirm that preventive behavior plays an important role as a protective factor against dengue fever. Respondents who took preventive measures, such as installing mosquito nets on windows and vents, routinely draining bathtubs, covering water containers, and destroying used items that could potentially become mosquito breeding sites, were found to have a lower risk of contracting dengue fever than those who did not take preventive measures. These results are consistent with research in northern Thailand that found preventive practices in households were correlated with a decrease in *Aedes* larvae density. Respondents who practiced prevention showed a better AOR compared to those who did not [19].

Water that has been polluted, both organic and inorganic compounds, will very easily become a medium for the development of various diseases. Polluted water can be stagnant (not flowing) water and it can also be flowing water. Infectious diseases due to water pollution can occur due to various reasons because water is a breeding ground for microorganisms, including microbes. There are many pathogenic microbes that breed in polluted water, causing various diseases and all of them are diseases that can be transmitted easily [39].

Furthermore, other studies show that lack of participation in anti-dengue programs (preventive behavior) is a significant risk factor for DHF infection, while physical aspects of the home categorized as healthy housing components show no significant difference between the case and control groups [13, 22].

In line with the findings of this study, efforts to prevent dengue fever are closely related to the Sustainable Development Goals (SDGs). Improving the physical condition of homes and strengthening preventive behaviors not only reduces the number of dengue fever cases but also supports the achievement of SDG 3 on good health and well-being, and SDG 11 on sustainable cities and communities. This means that healthy homes and clean-living behaviors are not merely individual needs, but also part of a global commitment to create safe, healthy, and livable environments for all [20, 21].

Despite its large population, this study has several limitations, such as the measurement of preventive behavior based on respondent interviews, so that potential recall bias and social desirability bias cannot be completely avoided. In addition, other environmental variables such as vector density outside the home, insecticide use, and microclimate factors were not examined. Therefore, further research with a cohort design or community-based intervention studies is needed to strengthen these findings.

Integrated Socio – Environmental Interpretation

Taken together, the newly added socio-demographic, WASH, housing, and PSN variables support a socio-environmental interpretation of dengue fever in South Sulawesi. Dengue prevention should not be framed only as a clinical response or fogging-based intervention. Instead, it should be understood as an integrated household and community health issue involving social vulnerability, WASH conditions, housing quality, waste management, and sustained mosquito breeding-site control. This integrated

interpretation is consistent with the Sustainable Development Goals, particularly SDG 3 on health, SDG 6 on water and sanitation, and SDG 11 on safe and sustainable settlements [37, 13].

The findings imply that dengue control in South Sulawesi should prioritize targeted community-based interventions in households and neighbourhoods with combined vulnerability: limited safe sanitation, poor waste management, non-livable housing conditions, and low 3M Plus implementation. Strengthening routine household inspection, community participation, larval surveillance, and behaviour change communication may improve the effectiveness of dengue prevention. Future analyses using survey-weighted multivariable regression are recommended to quantify the independent association of socio-demographic, WASH, housing, and PSN variables with dengue fever [38].

Conclusions

This study indicates that dengue fever in South Sulawesi is associated with interconnected socio-environmental factors, including household structural conditions, socio-demographic characteristics, WASH indicators, and PSN/3M practices. Housing conditions, particularly roof and floor characteristics, showed relevant associations with dengue fever, while WASH-related indicators and mosquito breeding-site control practices provide important contextual evidence of household environmental vulnerability. The inclusion of socio-demographic factors further highlights that dengue prevention should consider differences in residence, education, occupation, and household economic status.

Figure 5. Dengue Prevention in South Sulawesi within SDGs Framework

Given the cross-sectional design, these findings should be interpreted as associations rather than causal relationships. Nevertheless, the study contributes evidence that dengue control should move beyond clinical management and fogging toward integrated strategies combining housing improvement, WASH strengthening, targeted health promotion, community-based 3M Plus practices, and household-level vector surveillance. These actions are aligned with SDG 3, SDG 6, and SDG 11, and may support more effective dengue prevention policies in South Sulawesi.

Limitation

This study has several limitations. The cross-sectional design does not allow causal inference, so the findings should be interpreted as associations rather than causal relationships. Dengue fever was based on self-reported physician diagnosis within the previous year, which may be affected by recall bias, underdiagnosis, and differences in access to health services. Housing, WASH, and 3M/3M Plus variables were derived from secondary survey data and may not fully reflect the actual quality, frequency, or consistency of household prevention practices. The association between preventive behaviour and dengue fever may also be influenced by reverse causality, as households may adopt prevention practices after experiencing dengue. In addition, this study did not include entomological indicators, dengue serotypes, vector density, rainfall, temperature, humidity, or detailed spatial variables. Future studies

should integrate survey-weighted analysis, entomological surveillance, climate data, and spatial modelling to provide stronger evidence for dengue prevention in South Sulawesi.

Abbreviations

3M	: Draining, covering, and disposing/recycling/reusing potential mosquito breeding containers
3M Plus	: 3M practices combined with additional mosquito prevention measures
AOR	: Adjusted Odds Ratio
CI	: Confidence Interval
DBD	: Demam Berdarah Dengue
DF	: Dengue Fever
DHF	: Dengue Hemorrhagic Fever
IBM	: International Business Machines
LR	: Likelihood Ratio
OR	: Odds Ratio
PSN	: Mosquito Breeding-Site Eradication
SDGs	: Sustainable Development Goals
SKI	: Survei Kesehatan Indonesia / Indonesian Health Survey
SPSS	: Statistical Package for the Social Sciences
WASH	: Water, Sanitation and Hygiene
WHO	: World Health Organization

Declarations

Novelty

This study offers a novel socio-environmental perspective on dengue fever in South Sulawesi by integrating household structural conditions, sociodemographic characteristics, WASH indicators, and PSN/3M Plus practices using data from the 2023 Indonesian Health Survey. Rather than examining dengue solely through clinical occurrence, fogging response, or isolated housing components, this study frames dengue as a household-level environmental health issue shaped by housing vulnerability, water and sanitation conditions, waste management, and community-based mosquito breeding-site control. The study further strengthens its contribution by linking dengue prevention with SDG 3, SDG 6, and SDG 11, thereby providing evidence for integrated and policy-relevant dengue control strategies in South Sulawesi.

Ethics Approval and Consent to Participate

Human ethics and consent to participate: This study was reviewed and approved by the Health Research Ethics Committee of the Faculty of Public Health, Universitas Hasanuddin, Makassar, Indonesia

(approval number: 2571/UN4.14.1/TP.01.02/2025). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and applicable national research ethics guidelines. This secondary analysis used anonymized data from the 2023 Indonesian Health Survey. Consent to participate was obtained from all human participants during the original survey data collection. No new primary data collection, participant contact, or biological specimen collection was conducted by the authors, and respondent confidentiality was maintained throughout the analysis.

Consent to Participate

Informed consent was obtained from all participants before their participation in the 2023 Indonesian Health Survey. For participants under the age of 18 years, consent was obtained from their parents or legal guardians, and assent was obtained where applicable in accordance with the survey procedures. This study used anonymized secondary data from the 2023 Indonesian Health Survey; therefore, the authors did not collect new primary data directly from human participants. All data were analyzed in an anonymized form, and participant confidentiality was maintained throughout the study.

Clinical Trial Number

Clinical trial number: not applicable.

Consent for Publication

Not applicable.

Availability of Data and Materials

The data used in this study were derived from the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia, SKI), conducted by the Ministry of Health of the Republic of Indonesia through the Health Development Policy Agency. This study used secondary data related to dengue fever, socio-demographic characteristics, household structural conditions, water, sanitation and hygiene indicators, and mosquito breeding-site control practices in South Sulawesi Province. Aggregated indicators used for contextual interpretation are available in the official SKI 2023 report. Individual-level microdata are not publicly deposited by the authors and may be accessed through the official data request mechanism of the Ministry of Health of the Republic of Indonesia, subject to institutional approval and data use regulations. No new biological specimens, laboratory materials, or primary field materials were generated in this study. The derived tables, figures, and analytical outputs supporting the findings of this article are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare no competing interests.

Funding

This study did not receive any specific grant from funding agencies in the public, commercial, or not for profit sectors. The analysis was conducted using secondary data from the 2023 Indonesian Health Survey.

Authors' Contributions

Conceptualization, study design, methodology, validation, supervision, and writing—review & editing by S. Data curation, formal analysis, visualization, and writing—original draft by MAF and UWS. Literature review, discussion, and manuscript revision by GGG, RHP. All authors have read and approved the final version of the manuscript.

Acknowledgements

The authors would like to acknowledge the Ministry of Health of the Republic of Indonesia and the Health Development Policy Agency for providing access to the 2023 Indonesian Health Survey and official report. The authors also express their appreciation to the Faculty of Public Health, Universitas Hasanuddin, for academic support during the preparation of this manuscript. This study used secondary data, and no primary field data collection or biological specimen collection was conducted by the authors. The authors are also grateful to all respondents and field teams involved in the implementation of SKI 2023, whose contributions made this secondary analysis possible.

References

1. Rahmawati A, Markamah S, Blitar H, P.,K. Pengaruh Metode Edukasi Ceramah dan Diskusi Terhadap Pengetahuan Kader Kesehatan Dalam Deteksi Dini Demam Berdarah Dengue: Education Method of Lectures and Discussions toward Health Cadre Ability in Early Detection of Dengue Hemorrhagic Fever. *Jurnal Ilmiah Pamenang*. 2020;2(1):50–5. <https://doi.org/10.53599/JIP.V2I1.63>.
2. Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL, Drake JM, Brownstein JS, Hoen AG, Sankoh O, Myers MF, George DB, Jaenisch T, Wint W, Simmons GR, Scott CP, Farrar TW, J. J., Hay SI. The global distribution and burden of dengue. *Nature*. 2013;496(7446):504–7. <https://doi.org/10.1038/NATURE12060>;SUBJMETA.
3. Lim A, Shearer FM, Sewalk K, Pigott DM, Clarke J, Ghouse A, Judge C, Kang H, Messina JP, Kraemer MUG, Gaythorpe KAM, de Souza WM, Nsoesie EO, Celone M, Faria N, Ryan SJ, Rabe IB, Rojas DP, Hay SI, Brady OJ. The overlapping global distribution of dengue, chikungunya, Zika and yellow fever. *Nat Commun*. 2025;16(1):1–13. <https://doi.org/10.1038/S41467-025-58609-5>;TECHMETA.
4. Kemenkes. (2024). Profil Kesehatan Indonesia 2023. <https://kemkes.go.id/id/profil-kesehatan-indonesia-2023>

5. Mawaddah F, Pramadita S, Arundina A, Tejoyuwono T. Analisis Hubungan Kondisi Sanitasi Lingkungan Dan Perilaku Keluarga Dengan Kejadian Demam Berdarah Dengue di Kota Pontianak. *Jurnal Teknologi Lingkungan Lahan Basah*. 2022;10(2):215–28.
6. Osiniastasya O, Tosepu R, Prasetya F. *Jurnal Kendari Kesehatan Masyarakat*. 2025;4(3):285–93. <https://doi.org/10.37887/JKKM.V4I3.1343>. Hubungan Kondisi Lingkungan Dengan Kejadian Demam Berdarah Dengue (DBD) Diwilayah Kerja Puskesmas Kemaraya Kota Kendari Tahun 2024.
7. Wijirahayu S, Sukesu TW. Hubungan Kondisi Lingkungan Fisik dengan Kejadian Demam Berdarah Dengue di Wilayah Kerja Puskesmas Kalasan Kabupaten Sleman. *Indonesia*. 2019;18(1):19–24. <https://doi.org/10.14710/jkli.18.1.19-24>.
8. United Nations Department of Economic and Social Affairs. Sustainable Development Goal 3: Ensure healthy lives and promote well-being for all at all ages. United Nations.
9. United Nations Department of Economic and Social Affairs. Sustainable Development Goal 6: Ensure availability and sustainable management of water and sanitation for all. United Nations.
10. United Nations Department of Economic and Social Affairs. Sustainable Development Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable. United Nations.
11. Badan Kebijakan Pembangunan Kesehatan. *Survei Kesehatan Indonesia 2023 Dalam Angka*. Kementerian Kesehatan Republik Indonesia.
12. World Health Organization. Dengue and severe dengue. WHO Fact Sheet.
13. Hasalia AF, Noerjoedianto D, Damris M. Pneumonia Faktor-Faktor Lingkungan Fisik Terhadap Kejadian Pneumonia Balita di Puskesmas Kota Jambi: Faktor-Faktor Lingkungan Fisik Terhadap Kejadian Pneumonia Balita di Puskesmas Kota Jambi. *Jurnal Pembangunan Berkelanjutan*. 2025;8(1):34–51. <https://doi.org/10.22437/jpb.v8i1.40047>.
14. Aziz MH. Hubungan Karakteristik Lingkungan Fisik, Perilaku Masyarakat dan Densitas Larva Aedes Sp Dengan Kejadian DBD di Wilayah Kerja Puskesmas Antang Kota Makassar. *Relationship between Physical Environment Characteristics, Community Behavior and Density of Aedes Sp Larvae with DHF Incidence in Antang. Makassar City: Health Center Working Area*; 2024.
15. Quintero J, Brochero H, Manrique-Saide P, Barrera-Pérez M, Basso C, Romero S, Caprara A, De Lima Cunha JC, Beltrán - Ayala E, Mitchell-Foster K, Kroeger A, Sommerfeld J, Petzold M. Ecological, biological and social dimensions of dengue vector breeding in five urban settings of Latin America: A multi-country study. *BMC Infect Dis*. 2014;14(1):1–13. <https://doi.org/10.1186/1471-2334-14-38/TABLES/6>.
16. WHO. (2011). *Comprehensive guideline for prevention and control of dengue and dengue haemorrhagic fever*. <https://pesquisa.bvsalud.org/portal/resource/pt/who-204894>
17. Rinawan FR, Tateishi R, Raksanagara AS, Agustian D, Alsaaidh B, Natalia YA, Raksanagara A. Pitch and Flat Roof Factors' Association with Spatiotemporal Patterns of Dengue Disease Analysed Using Pan-Sharpned Worldview 2 Imagery. *ISPRS Int J Geo-Information* 2015. 2015;4(4):2586–603. <https://doi.org/10.3390/IJGI4042586>.

18. Kua KP, Lee SWH. Randomized trials of housing interventions to prevent malaria and Aedes-transmitted diseases: A systematic review and meta-analysis. PLoS ONE. 2021;16(1). <https://doi.org/10.1371/JOURNAL.PONE.0244284>.
19. Ismail NA, Haikhah J, Fauziah ET, Prabasunu MA, Rahma FH, Siswanto S, Widyasari V. Investigation of risk factors for household-based dengue virus infection in Borobudur Subdistrict. Magelang Indonesia Germs. 2024;14(3):277. <https://doi.org/10.18683/GERMS.2024.1438>.
20. Vásquez-Trujillo A, Cardona-Arango D, Segura-Cardona AM, Portela-Câmara DC, Alves-Honório N, Parra-Henao G. House-Level Risk Factors for Aedes aegypti Infestation in the Urban Center of Castilla la Nueva, Meta State, Colombia. J Trop Med. 2021;8483236. <https://doi.org/10.1155/2021/8483236>.
21. Ngugi HN, Mutuku FM, Ndenga BA, Musunzaji PS, Mbakaya JO, Aswani P, Irungu LW, Mukoko D, Vulule J, Kitron U, LaBeaud AD. Characterization and productivity profiles of Aedes aegypti (L.) breeding habitats across rural and urban landscapes in western and coastal Kenya. Parasites Vectors. 2017;10(1):1–12. <https://doi.org/10.1186/S13071-017-2271-9/FIGURES/4>.
22. Hoyochi I, Padonou GG, Tokponnon TF, Konkon AK, Zoungbédji DM, Salako AS, Dangnon B, Akowanou AVO, Sintondji LO, Sossoukpe E, Baba-Moussa L, Akogbéto MC. Influence of the physicochemical characteristics of mosquito breeding sites in domestic environments on the distributions of Anopheles, Aedes and Culex mosquitoes in Benin. Trop Med Health. 2025;53(1):1–13. <https://doi.org/10.1186/S41182-025-00786-6/FIGURES/6>.
23. Seang-arwut C, Hanboonsong Y, Muenworn V, Rocklöv J, Haque U, Ekalaksananan T, Paul RE, Overgaard HJ. Indoor resting behavior of Aedes aegypti (Diptera: Culicidae) in northeastern Thailand. Parasites Vectors. 2023;16(1):1–14. <https://doi.org/10.1186/S13071-023-05746-9/FIGURES/6>.
24. Thongkham J, Kanrew K, Wongkumthi C, Intasan N, Saita S, Vittaporn S, Pongpan S, Khamnuan P, Wattanasoei S, Pooseeod K. Health beliefs and housing environmental factors affecting dengue prevention and Aedes larvae in rural northern Thailand: a cross-sectional study. Discover Social Sci Health. 2025;5(1):1–14. <https://doi.org/10.1007/S44155-025-00260-Y/TABLES/6>.
25. (2022). *Global strategy for dengue prevention and control 2021–2030*. WHO, Geneva. https://cdn.who.int/media/docs/default-source/malaria/vcag-documentation/vcag-nov2019-ntd-update.pdf?sfvrsn=3305c6be_2
26. Badan Kebijakan Pembangunan Kesehatan. Survei Kesehatan Indonesia 2023 dalam angka. Kementerian Kesehatan Republik Indonesia; 2024.
27. World Health Organization. Dengue and severe dengue. WHO Fact Sheet; 2025.
28. Man O, et al. Characterizing dengue transmission in rural areas. PLOS Neglected Tropical Diseases; 2023.
29. Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL, Drake JM, Brownstein JS, Hoen AG, Sankoh O, Myers MF, George DB, Jaenisch T, Wint GRW, Simmons CP, Scott TW, Farrar JJ, Hay SI.

- The global distribution and burden of dengue. *Nature*. 2013;496(7446):504–7.
<https://doi.org/10.1038/nature12060>.
30. Getachew D, Tekie H, Gebre-Michael T, Balkew M, Mesfin A. (2015). Breeding sites of *Aedes aegypti*: Potential dengue vectors in Dire Dawa, East Ethiopia. *Interdisciplinary Perspectives on Infectious Diseases*, 2015, 706276.
 31. Nurjana MA et al. (2023). Water containers and the preferable conditions for laying eggs by *Aedes* mosquitoes. *Acta Trop*.
 32. Hoyochi I, Padonou GG, Tokponnon TF, Konkon AK, Zoungbédji DM, Salako AS, Dangnon B, Akowanou AVO, Sintondji LO, Sossoukpe E, Baba-Moussa L, Akogbéto MC. (2025). Influence of the physicochemical characteristics of mosquito breeding sites in domestic environments on the distributions of *Anopheles*, *Aedes* and *Culex* mosquitoes in Benin. *Tropical Medicine and Health*, 53, Article 1. <https://doi.org/10.1186/s41182-025-00786-6>
 33. Quintero J, Brochero H, Manrique-Saide P, Barrera-Pérez M, Basso C, Romero S, Caprara A, De Lima Cunha JC, Beltrán-Ayala E, Mitchell-Foster K, Kroeger A, Sommerfeld J, Petzold M. Ecological, biological and social dimensions of dengue vector breeding in five urban settings of Latin America: A multi-country study. *BMC Infect Dis*. 2014;14:38. <https://doi.org/10.1186/1471-2334-14-38>.
 34. Herath JMMK, et al. Breeding habitat preference of the dengue vector *Aedes aegypti* and *Aedes albopictus*. *Parasites & Vectors*; 2024.
 35. Montenegro-Quiñonez CA, et al. Interventions against *Aedes*/dengue at the household level: A systematic review. *Parasites & Vectors*; 2023.
 36. Kementerian Kesehatan Republik Indonesia. Pemberantasan sarang nyamuk dengan 3M Plus. Ayo Sehat Kemenkes; 2023.
 37. Lusno MFD, et al. The need for active and integrated involvement of the community in dengue prevention and control. *Journal/PMC Article*; 2024.
 38. United Nations. Transforming our world: The 2030 Agenda for Sustainable Development. United Nations; 2015.
 39. Girikallo GG, Ishak SMH, Amqam H, Hidayanty H. Andi Ummu Salmah, Rudi Hendro Purtanto, Amir Su'udi, Adrianus Surianto Girikallo, Setiawan Kasim (2024). Risk Factors for Schistosomiasis in East Lore District Poso Regency Central of Sulawesi Province, Indonesia. *Univers J Public Health*, 12(6), 1070–83. [10.13189/ujph.2024.120605](https://doi.org/10.13189/ujph.2024.120605)
 40. Tangel YEA, Ishak H, Ibrahim E, Manyullei S, Wahid IWahiduddin. Risk Factors of the Physical Environment of the House and Larva Habitat on the Incident of Malaria in the Working Area of the Tambelang Public Health Center Southeast Minahasa Regency. *Univers J Public Health*. 2024;12(4):746–58. [10.13189/ujph.2024.120414](https://doi.org/10.13189/ujph.2024.120414).
 41. Manyullei S, Mangedong S, Nasrah Nasrah. Muh. Fajar Natsir, &. (2026). Environmental Sanitation and Household Rodent Presence Among Suspected Leptospirosis Cases: Findings from Makassar, Indonesia. *Media Publikasi Promosi Kesehatan Indonesia (MPPKI)*, 9(5), 901–914.
<https://doi.org/10.56338/mppki.v9i5.9143>

Figures

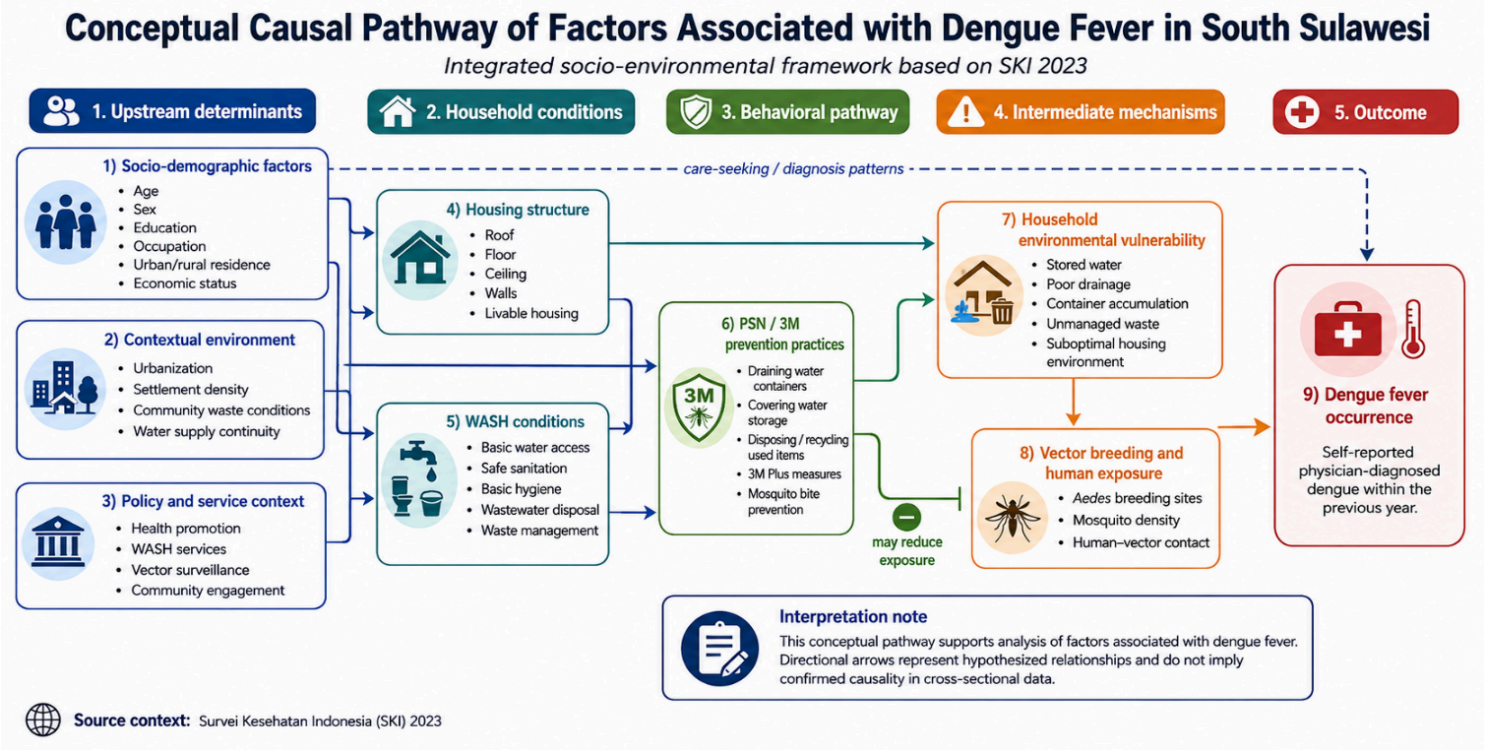
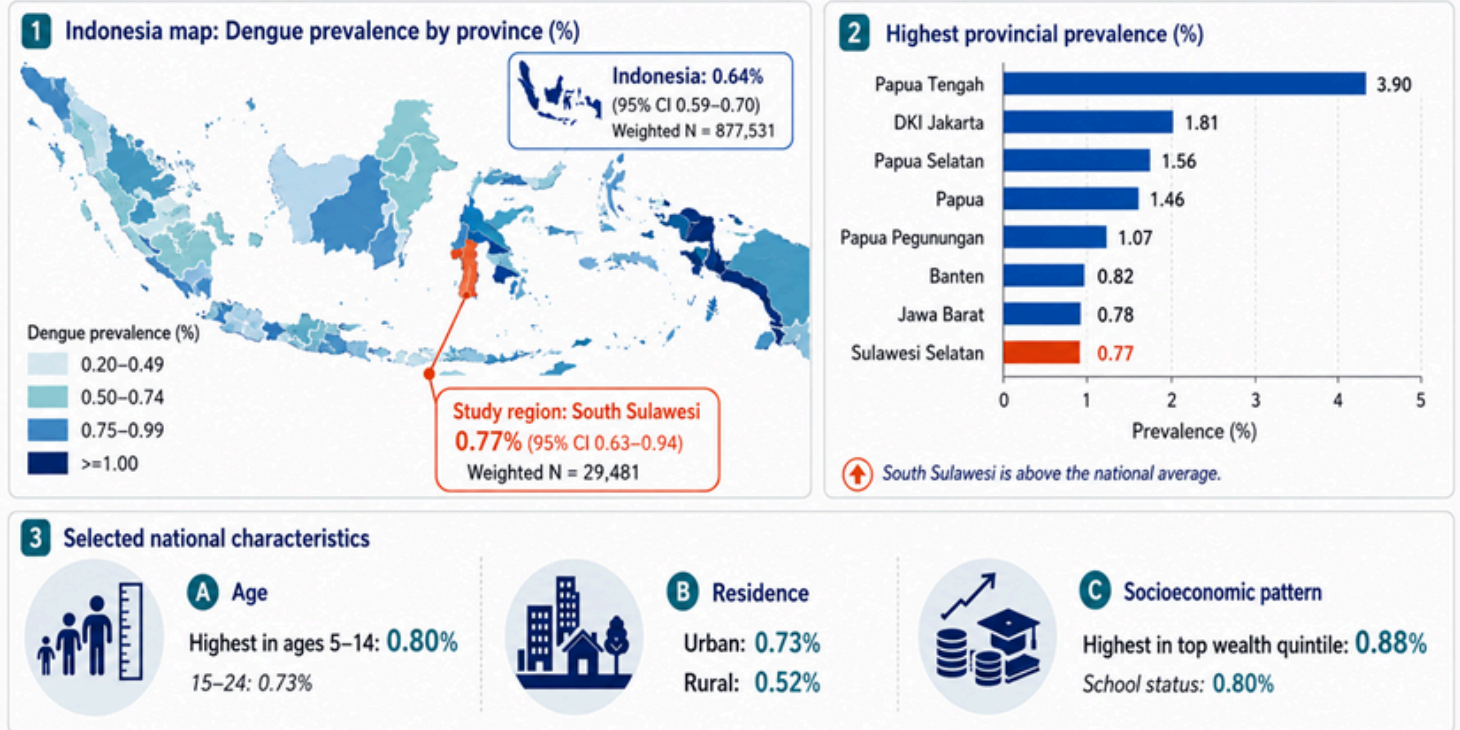


Figure 1

Causal Pathway Diagram

Dengue Fever in Indonesia: SKI 2023 National Pattern

Provincial prevalence and study focus in South Sulawesi



Source: Survei Kesehatan Indonesia (SKI) 2023, Table 6.33 and Table 6.34. Dengue fever defined as self-reported physician-diagnosed dengue within the previous year.

Figure 2

Dengue Fever in Indonesia: SKI 2023 National Pattern

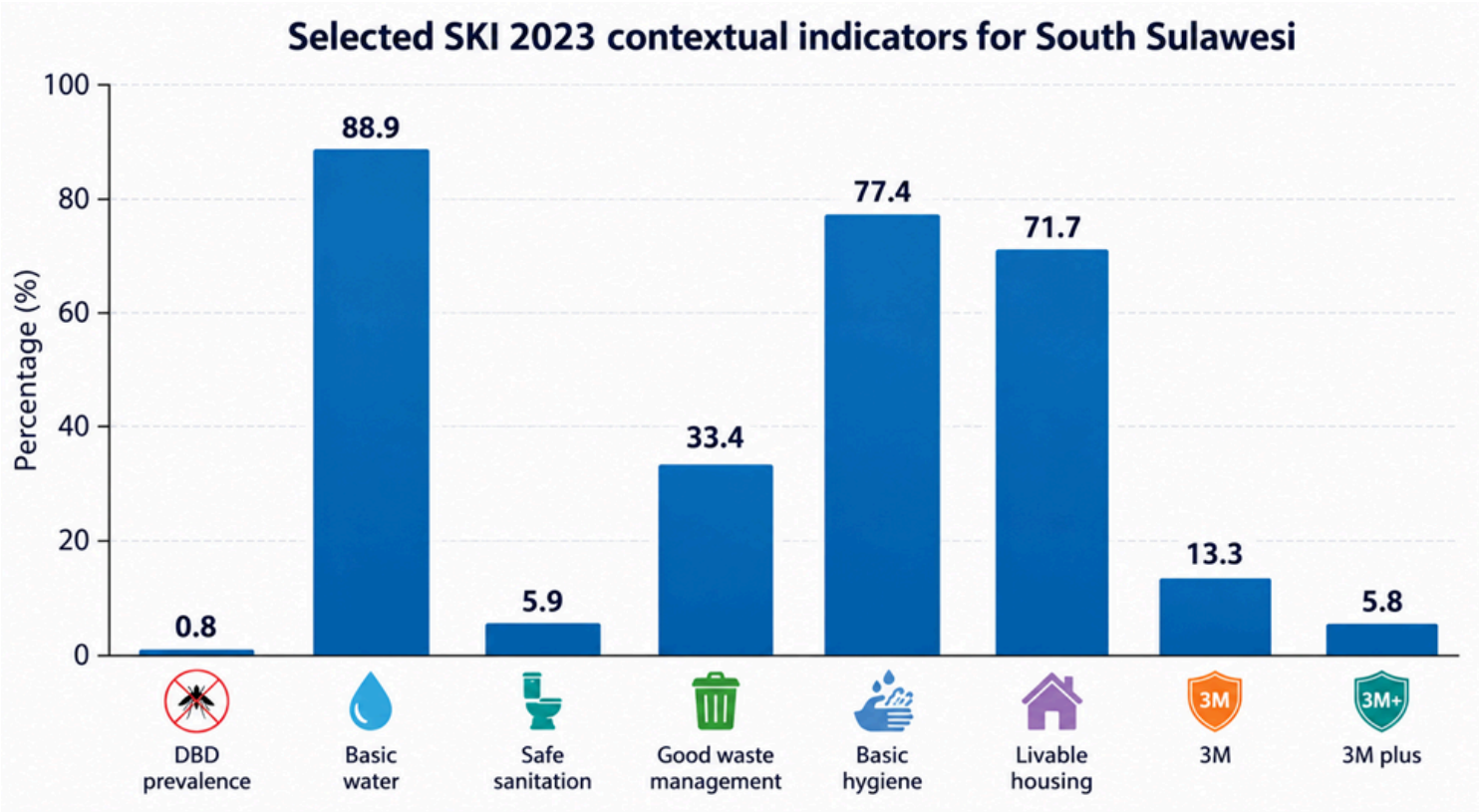


Figure 3

Selected Contextual Indicators for Dengue Related Environmental Vulnerability in South Sulawesi

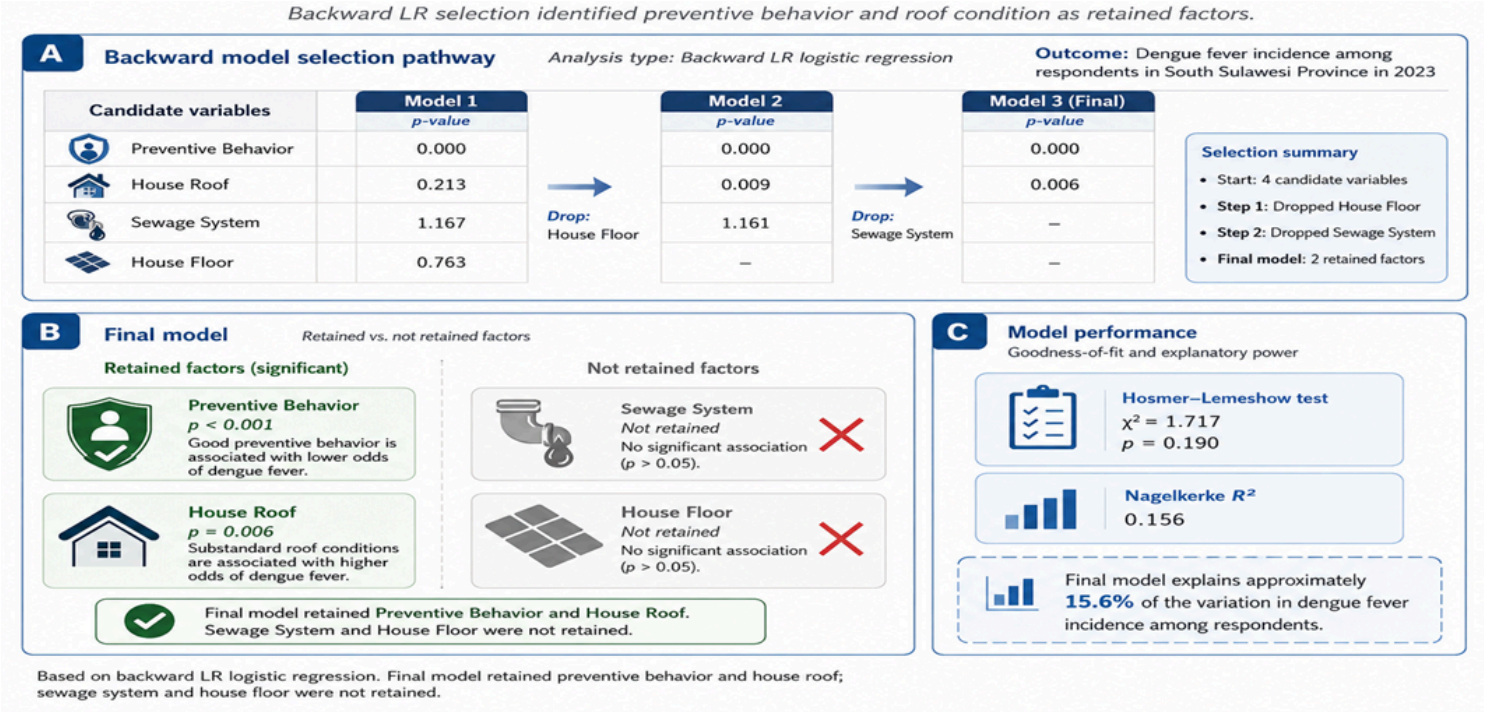


Figure 4

Logistic Regression Summary of Factors Associated with Dengue Fever in South Sulawesi, 2023.

Dengue Prevention in South Sulawesi within the SDG 3, SDG 6, and SDG 11 Framework

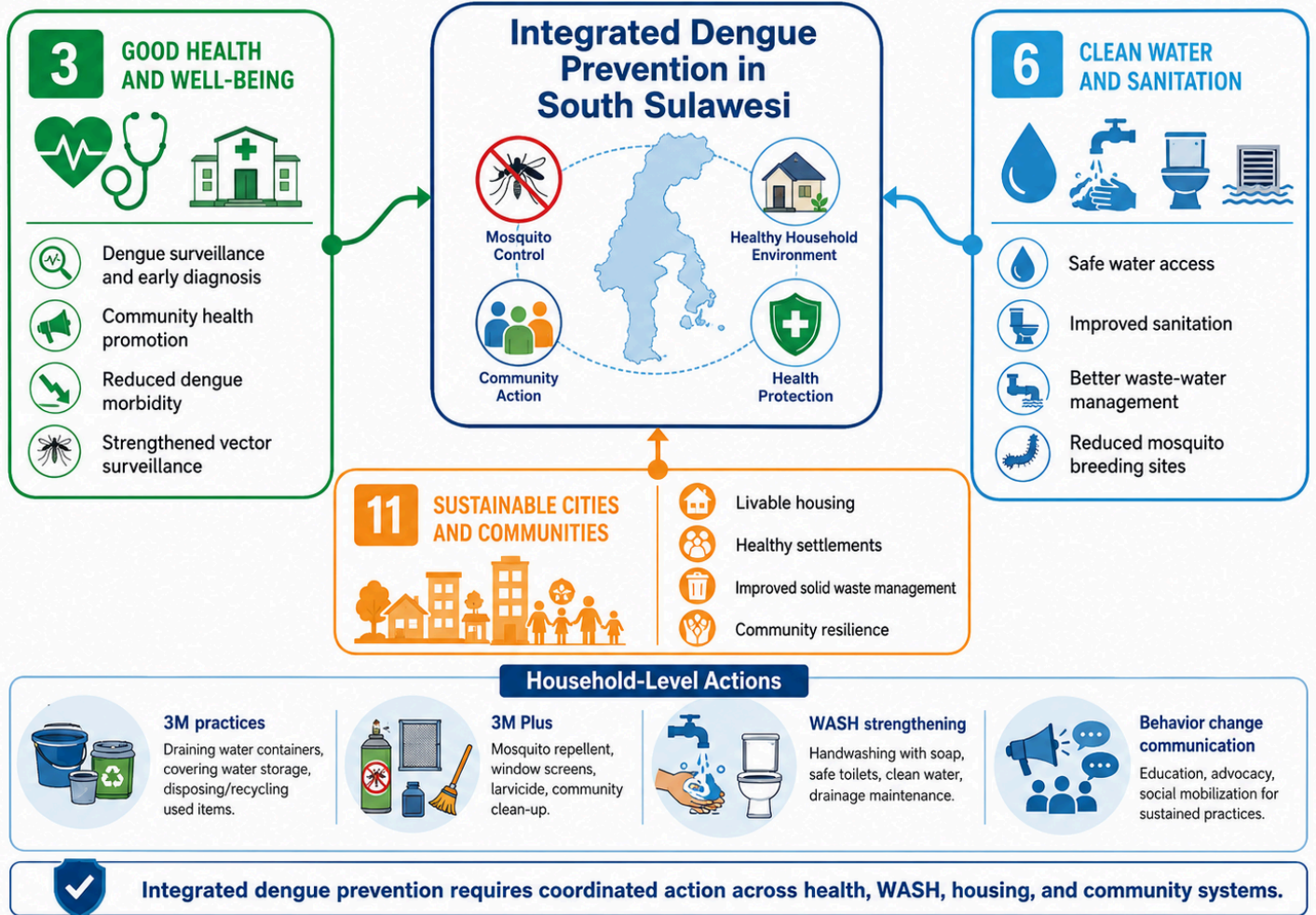


Figure 5

Dengue Prevention in South Sulawesi within SDGs Framework