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Behavioral and Environmental Determinants of Community-Based Dengue Prevention in Timor-Leste: A Narrative Review Using the Precede–Proceed Model

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ABSTRACT

Background: Dengue remains a significant public health challenge in tropical and subtropical regions, particularly in countries where environmental conditions, urbanization, and limitations in community-level preventive practices contribute to mosquito-borne disease transmission. In Timor-Leste, dengue is endemic throughout the year, with transmission generally increasing during the rainy season. The epidemiological experience in Dili between 2018 and 2022, which recorded 6,234 notified cases and 55 deaths, demonstrates the continuing importance of strengthening community-based prevention (Machado et al., 2024).

Objective: This article examines the behavioral, social, and environmental determinants of dengue prevention in Timor-Leste through the application of Lawrence W. Green's PRECEDE–PROCEED Model. It aims to develop a theoretical and public health perspective for strengthening community participation and sustainable dengue prevention strategies.

Methods: A narrative literature review approach is employed to examine relevant scientific publications, public health reports, and theoretical literature concerning dengue epidemiology, health promotion, community participation, and environmental determinants. The PRECEDE–PROCEED Model provides the analytical framework for organizing the discussion around predisposing, enabling, and reinforcing factors, alongside broader behavioral and environmental conditions.

Discussion: The analysis focuses on the relationship between community knowledge, preventive attitudes, household practices, environmental sanitation, access to health information, institutional support, and collective participation. It also considers how these interconnected determinants can inform culturally appropriate and sustainable dengue prevention interventions in Timor-Leste.

Conclusion: Effective dengue prevention requires more than vector-control activities and individual behavioral change. It demands an integrated community-based approach that connects health education, environmental management, institutional commitment, and active community participation. The PRECEDE–PROCEED Model offers a useful framework for understanding these relationships and informing context-sensitive public health strategies in Timor-Leste.

Keywords: Dengue Prevention; Community Participation; Timor-Leste; PRECEDE–PROCEED Model; Behavioral Determinants; Environmental Health; Health Promotion.

1. INTRODUCTION

Dengue is one of the most important mosquito-borne viral diseases affecting public health in tropical and subtropical regions. Its increasing geographical distribution, recurrent outbreaks, and potential to cause severe illness and death have made dengue prevention a continuing priority for national health systems and international public health organizations. The disease is primarily transmitted through the bite of infected female *Aedes aegypti* mosquitoes, although other mosquito species, including *Aedes albopictus*, may also contribute to transmission. According to the World Health Organization (WHO, 2025), approximately half of the world's population is at risk of dengue infection, with an estimated 100–400 million infections occurring annually. The reported global burden increased substantially, reaching approximately 14.6 million reported cases in 2024. This growing burden reflects the complex interaction between climatic conditions, urbanization, population mobility, environmental management, and the capacity of public health systems to implement effective prevention and control measures.

In Timor-Leste, dengue represents a persistent public health concern, particularly during periods of increased rainfall and mosquito activity. The country experiences dengue

transmission throughout the year, with higher transmission generally reported during the rainy season. The World Health Organization (2022) documented a substantial increase in dengue cases in late 2021 and early 2022, highlighting the vulnerability of the national health system to recurrent outbreaks. During January 2022 alone, 1,286 cases and 20 deaths were reported, with children accounting for a considerable proportion of reported cases. Dili Municipality experienced the highest concentration of cases during this period, demonstrating the importance of strengthening local surveillance, prevention, and community-based health interventions.

Further evidence of the magnitude of the problem is provided by Machado et al. (2024), who examined dengue epidemiology in Dili Municipality between 2018 and 2022. Their study documented 6,234 reported dengue cases and 55 deaths, with a mean annual incidence of 330 cases per 100,000 population. The highest annual incidence occurred in 2022, when 3,904 cases were recorded, including 760 cases classified as dengue haemorrhagic fever and 35 deaths. The outbreak also placed considerable pressure on hospital services, requiring the adaptation of existing health facilities to accommodate the increased demand for treatment. These findings demonstrate that dengue prevention in Timor-Leste requires sustained attention not only to clinical preparedness and disease surveillance but also to the social and environmental conditions that influence transmission at the household and community levels.

Lawrence W. Green's PRECEDE–PROCEED Model offers a relevant theoretical framework for examining these interconnected determinants. Developed as an approach to health program planning, the model emphasizes the importance of identifying the social, epidemiological, behavioral, environmental, educational, and organizational conditions associated with a particular health problem before designing interventions (Green & Kreuter, 2005). Its educational and ecological assessment identifies three major categories of behavioral determinants: predisposing factors, enabling factors, and reinforcing factors. Predisposing factors include knowledge, attitudes, beliefs, values, and perceptions that influence motivation to adopt health-related behaviors. Enabling factors encompass the resources, skills, services, and environmental conditions that make preventive actions possible. Reinforcing factors involve the social and institutional support that encourages individuals and communities to maintain desirable behaviors. The model also connects these determinants with broader processes of intervention implementation and evaluation (Crosby & Noar, 2011; Porter, 2016).

The application of the PRECEDE–PROCEED Model to dengue prevention is particularly relevant because mosquito-borne disease transmission cannot be adequately addressed through individual knowledge or isolated vector-control activities alone. For example, a household may understand the importance of eliminating stagnant water but remain unable to maintain effective environmental sanitation because of inadequate waste collection or drainage infrastructure. Similarly, community members may demonstrate positive attitudes toward dengue prevention but lack consistent support from local institutions, health professionals, or neighborhood organizations. Such situations illustrate the distinction between individual motivation and the broader enabling and reinforcing conditions required to translate health knowledge into sustained preventive practices. By incorporating both behavioral and environmental assessments, the model provides an analytical basis for identifying these barriers and developing interventions that are responsive to community needs.

Accordingly, this article examines community-based dengue prevention in Timor-Leste through a narrative literature review informed by Lawrence W. Green's PRECEDE–PROCEED Model. Specifically, it explores the behavioral and environmental determinants of dengue prevention by examining predisposing, enabling, and reinforcing factors, as well as the broader social and institutional conditions influencing community participation. It also discusses the implications of these determinants for health education, nursing practice, environmental management, and public health policy. By integrating epidemiological evidence with behavioral and ecological perspectives, this article seeks to develop a context-sensitive conceptual understanding of how community participation and coordinated preventive strategies can contribute to more sustainable dengue prevention and stronger population health protection in Timor-Leste.

2. THEORETICAL FRAMEWORK: LAWRENCE W. GREEN'S PRECEDE–PROCEED MODEL

2.1. Conceptual Foundations of the PRECEDE–PROCEED Model

The PRECEDE–PROCEED Model, developed by Lawrence W. Green and colleagues, provides a framework for planning, implementing, and evaluating health promotion

programmes. PRECEDE focuses on diagnosing behavioral and environmental determinants through predisposing, enabling, and reinforcing factors, while PROCEED addresses programme implementation and evaluation (Green et al., 1980; Green & Kreuter, 2005). Its ecological perspective recognizes that health behaviors are shaped not only by individual knowledge and attitudes but also by social relationships, institutional resources, and environmental conditions (Crosby & Noar, 2011). For dengue prevention, the model helps explain how household practices interact with water access, sanitation, waste management, community participation, and institutional support.

2.2. The PRECEDE Component: Social, Epidemiological, Behavioral, and Environmental Assessment

The PRECEDE component begins by assessing community needs, quality of life, and the determinants of health to guide appropriate interventions (Green & Kreuter, 2005; Crosby & Noar, 2011). In dengue prevention in Timor-Leste, this process involves four areas: (1) **social assessment**, examining the impact of dengue on family and community well-being; (2) **epidemiological assessment**, identifying disease burden, mortality, and population risks (Machado et al., 2024); (3) **behavioral and environmental assessment**, identifying household practices and conditions that contribute to mosquito breeding; and (4) **educational and ecological assessment**, identifying predisposing, enabling, and reinforcing factors that influence preventive behaviors.

2.3. Predisposing Factors: Knowledge, Attitudes, Beliefs, and Perceptions

Predisposing factors are individual and collective characteristics, including knowledge, attitudes, beliefs, values, and risk perceptions, that motivate health-related behaviors (Green & Kreuter, 2005). In dengue prevention, understanding transmission, mosquito breeding sites, preventive measures, and warning signs can encourage household and community action. However, misconceptions, low perceived risk, and limited personal responsibility may weaken participation. In Timor-Leste, health education should therefore be culturally appropriate and delivered through accessible channels, including nurses, community health workers, schools, and local leaders. Nevertheless, knowledge alone cannot ensure behavioral change, particularly

when inadequate water supply, drainage, and waste management constrain preventive practices. Predisposing factors must therefore be addressed alongside enabling and reinforcing conditions.

2.4. Enabling Factors: Resources, Skills, Services, and Environmental Conditions

Enabling factors refer to the resources, skills, services, and environmental conditions that facilitate or prevent individuals and communities from translating health knowledge and motivation into practical action. These factors include the availability and accessibility of health services, relevant facilities, financial and material resources, organizational support, and opportunities to perform preventive behaviors (Green & Kreuter, 2005).

In dengue prevention, enabling factors include access to appropriate waste-disposal facilities, reliable water supplies, adequate drainage, household water-storage containers with secure covers, mosquito-control resources, and accessible health information. The availability of trained community health workers and nurses also contributes to the capacity of communities to identify risks, receive health education, and participate in preventive activities.

Environmental infrastructure is especially important because dengue prevention requires more than individual willingness. For example, households may be encouraged to maintain clean surroundings and eliminate stagnant water, but these efforts may be undermined by inadequate drainage systems, irregular waste collection, or environmental conditions beyond individual control. In such circumstances, sustainable prevention requires cooperation between households, community organizations, local authorities, and relevant government institutions.

In the Timor-Leste context, enabling interventions should therefore consider differences in environmental infrastructure and access to public health resources across municipalities and communities. Local prevention programs should identify practical barriers before recommending behavioral changes that households may not be able to implement independently. Community-based dengue prevention becomes more achievable when educational messages are accompanied by accessible resources, appropriate infrastructure, and institutional assistance.

2.5. Reinforcing Factors: Family, Community, Health Professionals, and Institutional Support

Reinforcing factors are social and institutional influences that encourage and sustain health behaviors, including family support, community leadership, peer encouragement, and feedback from health professionals (Green & Kreuter, 2005). In dengue prevention, these factors promote consistent household practices and collective environmental action. Families, schools, local leaders, nurses, and community health workers can reinforce preventive behaviors through education, household visits, and community clean-up activities. In Timor-Leste, coordination among health services, local authorities, educational institutions, and community organizations is essential to ensure that dengue prevention becomes a continuous community practice rather than an occasional campaign.

2.6. The PROCEED Component: Implementation, Monitoring, and Evaluation

While PRECEDE identifies health determinants and guides intervention planning, PROCEED focuses on implementation, organizational support, and evaluation (Green & Kreuter, 2005). It comprises four phases: **Phase 5 (Implementation)** involves delivering planned dengue prevention activities; **Phase 6 (Process Evaluation)** assesses whether activities are implemented as intended; **Phase 7 (Impact Evaluation)** examines changes in knowledge, attitudes, preventive practices, and environmental conditions; and **Phase 8 (Outcome Evaluation)** assesses long-term effects, including dengue incidence, severe cases, and mortality. Together, these phases support programme monitoring, institutional accountability, and continuous improvement.

2.7. Application of the PRECEDE–PROCEED Model to Community-Based Dengue Prevention in Timor-Leste

Applying the PRECEDE–PROCEED Model to dengue prevention in Timor-Leste connects individual behavior with broader social, environmental, and institutional conditions. Predisposing interventions strengthen knowledge and risk awareness; enabling interventions improve access to water management, waste disposal, and environmental sanitation; and reinforcing interventions promote family support, community leadership, and health-worker

engagement. Through PROCEED, these activities can be implemented, monitored, and evaluated using appropriate indicators. Their application should reflect differences between urban and rural communities, cultural practices, and available resources. Ultimately, the model promotes community participation, shared responsibility, and sustainable dengue prevention through coordinated public health action.

2.8. Conceptual Synthesis

Based on the PRECEDE–PROCEED Model, this article conceptualizes community-based dengue prevention as the result of interactions among behavioral, social, environmental, and institutional determinants. Predisposing factors influence motivation and willingness to adopt preventive behaviors; enabling factors determine whether individuals and communities have the practical resources and opportunities to implement those behaviors; and reinforcing factors contribute to their continuation through social support and institutional encouragement.

These three categories interact with environmental conditions and the broader organization of public health services. Their combined influence may strengthen or constrain household and community preventive practices. The PROCEED component provides the planning and evaluation perspective through which interventions can be implemented, monitored, and assessed.

Accordingly, the framework used in this article proposes that sustainable dengue prevention in Timor-Leste requires the integration of health education, accessible resources, environmental management, community participation, and institutional coordination. This conceptual perspective provides the foundation for the subsequent analysis of epidemiological, behavioral, and environmental evidence concerning dengue prevention in the country.

3. METHODOLOGY

3.1. Study Design

This article adopts a narrative literature review design to examine community-based dengue prevention in Timor-Leste through Green's PRECEDE–PROCEED Model. This approach enables critical interpretation of interconnected epidemiological, behavioral, environmental,

and health-system dimensions. Narrative reviews support knowledge synthesis, conceptual integration, and identification of evidence gaps (Sukhera, 2022). Methodological transparency is strengthened through clear objectives, explicit selection criteria, critical evidence interpretation, and appropriate referencing. The review also follows SANRA principles, emphasizing review justification, literature search description, scientific reasoning, and accurate referencing (Baethge et al., 2019).

3.2. Literature Sources and Search Strategy

Relevant literature was identified through targeted searches of publicly accessible scientific and institutional sources, including PubMed, journal websites, WHO publications, and institutional repositories. Searches addressed dengue epidemiology, community participation, health education, behavioral and environmental determinants, vector control, and PRECEDE–PROCEED. Search terms included “Dengue” and “Timor-Leste,” “community-based dengue prevention,” “behavioral determinants,” and “PRECEDE–PROCEED Model.” Reference lists were also examined for additional relevant sources. The search was purposive and iterative, updated through November 2026, and aimed at identifying credible literature for critical synthesis rather than exhaustive retrieval (Sukhera, 2022).

3.3. Inclusion and Exclusion Criteria

Literature was considered relevant for inclusion when it contributed to one or more of the central themes of the review. Priority was given to publications meeting the following criteria:

1. Scientific studies addressing dengue epidemiology, prevention, transmission, vector control, or disease surveillance.
2. Research examining knowledge, attitudes, beliefs, preventive practices, and other behavioral determinants associated with dengue prevention.
3. Publications discussing environmental determinants, including household water management, waste disposal, drainage, sanitation, and mosquito breeding-site reduction.
4. Studies and reports addressing community participation, health education, nursing interventions, and public health promotion.
5. Theoretical and methodological publications explaining the PRECEDE–PROCEED Model and its application to health promotion.

6. Official reports and institutional publications from the World Health Organization and relevant Timor-Leste health authorities.
7. Publications providing contextual evidence from Timor-Leste, particularly Dili Municipality, as well as relevant evidence from other dengue-endemic settings when national evidence was limited.

Publications were considered for exclusion when they were unrelated to the objectives of the review, lacked sufficient methodological or contextual information, duplicated information already represented by a more authoritative source, or consisted of unsupported claims without identifiable evidence. Non-peer-reviewed institutional materials were not automatically excluded when they provided relevant official epidemiological information, public health guidance, or policy context. However, their institutional origin and evidentiary limitations were considered during interpretation.

3.4. Literature Selection and Critical Appraisal

Literature selection involved assessing titles, abstracts, relevance, methodological clarity, and source credibility. Priority was given to studies addressing dengue prevention in Timor-Leste, while international literature provided comparative insights. Scientific and institutional sources were evaluated according to their methods, evidence, and limitations. SANRA principles guided critical interpretation and transparent referencing (Baethge et al., 2019). As this was a narrative review, exhaustive retrieval and independent duplicate screening are not claimed. No numerical selection totals or PRISMA flow diagram are presented because a documented systematic screening dataset was not established.

3.5. Data Extraction and Thematic Organization

Relevant information from the selected literature was organized according to the main objectives and theoretical framework of the review. The extraction process focused on the following dimensions:

- **Bibliographic characteristics:** authorship, publication year, publication type, and geographical context.
- **Epidemiological information:** dengue incidence, reported cases, severe disease, mortality, and relevant population characteristics.

- **Behavioral determinants:** knowledge, attitudes, beliefs, risk perceptions, household practices, and preventive behaviors.
- **Environmental determinants:** water-storage practices, drainage, waste management, sanitation, and mosquito breeding-site conditions.
- **Community and institutional determinants:** family support, community participation, health education, nursing involvement, and institutional coordination.
- **Theoretical contributions:** the relevance of predisposing, enabling, and reinforcing factors within the PRECEDE–PROCEED Model.

The extracted information was organized into thematic categories to facilitate comparison and interpretation across different evidence sources. Particular attention was given to the relationship between individual preventive behavior and the environmental and institutional conditions that influence the ability of communities to implement and sustain preventive practices.

3.6. Thematic Synthesis and Analytical Framework

A narrative thematic synthesis was employed to integrate the findings and conceptual contributions of the identified literature. The synthesis was guided by Lawrence W. Green's PRECEDE–PROCEED Model, particularly its educational and ecological assessment dimensions.

Three principal analytical categories were established:

1. Predisposing factors. This category examined knowledge, attitudes, beliefs, values, and perceptions that influence individual and community motivation to participate in dengue prevention.

2. Enabling factors. This category examined the resources, skills, health services, environmental infrastructure, and practical opportunities necessary to translate preventive knowledge into action.

3. Reinforcing factors. This category examined the influence of family support, community leadership, neighborhood cooperation, health professionals, and institutional commitment in sustaining preventive behaviors.

The synthesis was interpretive rather than statistical. Findings were not pooled quantitatively, and no meta-analysis was undertaken. Instead, the review sought to identify recurring themes, contextual differences, theoretical relationships, and implications for public health practice in Timor-Leste.

3.7. Methodological Limitations

Several limitations should be considered when interpreting this review. First, the narrative literature review design does not provide the exhaustive coverage or formal reproducibility associated with a systematic review. The selection and interpretation of literature may therefore be influenced by the availability, accessibility, and relevance of published sources.

Second, the availability of peer-reviewed research specifically addressing behavioral and environmental determinants of dengue prevention in Timor-Leste remains limited in comparison with the broader international dengue literature. Consequently, some analytical perspectives draw on evidence from other dengue-endemic countries. Such evidence is used for contextual comparison and theoretical interpretation rather than as direct proof of conditions in Timor-Leste.

Third, differences in research designs, geographical settings, population characteristics, and outcome measures limit direct comparisons between studies. Institutional reports and public health documents may also differ in their reporting methods and levels of detail.

Finally, the application of the PRECEDE–PROCEED Model in this article is conceptual and analytical. No primary data were collected, no community intervention was implemented, and no causal relationship between the identified determinants and dengue incidence was experimentally tested. Therefore, the proposed implications should be understood as evidence-informed recommendations that require further evaluation in the Timor-Leste context.

4. RESULTS AND THEMATIC ANALYSIS

4.1. Dengue Epidemiology and Public Health Implications in Timor-Leste

Dengue represents a continuing epidemiological challenge in Timor-Leste, with transmission occurring throughout the year and increasing during periods of higher rainfall. The

concentration of cases during the rainy season highlights the relationship between climatic conditions, mosquito breeding opportunities, environmental management, and population vulnerability. The World Health Organization (WHO, 2022) documented a substantial increase in dengue cases in late 2021 and early 2022. In January 2022 alone, Timor-Leste reported 1,286 cases and 20 deaths, with children younger than 14 years accounting for 790 reported cases. Dili Municipality experienced the greatest concentration of cases during this period, demonstrating the importance of strengthening surveillance, clinical preparedness, and community-level preventive activities.

Further epidemiological evidence is provided by Machado et al. (2024), who examined reported dengue cases in Dili Municipality between 2018 and 2022. Their study documented 6,234 cases, with a mean annual incidence rate of 330 cases per 100,000 population and 55 reported deaths. The highest annual incidence occurred in 2022, when 3,904 cases were recorded, including 760 cases classified as dengue haemorrhagic fever and 35 deaths. The outbreak also placed considerable pressure on hospital services, requiring the adaptation of facilities originally established for COVID-19 isolation and treatment.

These findings indicate that dengue prevention in Timor-Leste requires an approach that extends beyond responding to outbreaks after transmission has intensified. Sustained preventive measures should address the environmental and behavioral conditions that facilitate mosquito reproduction and human exposure. The epidemiological burden also demonstrates the importance of identifying vulnerable populations, strengthening early health-seeking behavior, and maintaining community-based surveillance.

4.2. Community Knowledge and Awareness of Dengue Prevention

Community knowledge and awareness are important predisposing factors in dengue prevention. Understanding transmission, breeding sites, warning signs, and preventive practices can encourage household participation. However, knowledge does not always ensure consistent action. Jeronimo (2017), surveying 381 households in Dili, found mosquito larvae in 22.04% of households and potential breeding sites in 60.56%. Only 17.6% consistently practiced chemical treatment and environmental management. Cruz et al. (2024) also highlighted knowledge, attitudes, preventive behavior, and environmental conditions. National awareness

campaigns further demonstrate institutional efforts to strengthen community understanding (Government of Timor-Leste, 2026).

4.3. Behavioral Determinants of Dengue Prevention

Behavioral determinants play a central role in the effectiveness of community-based dengue prevention. Household practices, individual responsibility, risk perception, and the consistency of preventive activities influence opportunities for mosquito breeding and human exposure. Important preventive behaviors include covering and regularly cleaning water-storage containers, removing discarded objects that collect water, maintaining clean household surroundings, and participating in neighborhood environmental activities.

The findings reported by Jeronimo (2017) are particularly relevant because they demonstrate that favorable knowledge and attitudes do not automatically translate into consistent preventive practices. The discrepancy between reported knowledge and observed breeding sites suggests that behavioral change requires more than awareness. It also requires practical skills, regular reinforcement, access to preventive resources, and opportunities for collective action.

Cruz et al. (2024) similarly identified knowledge, attitudes, and preventive behavior as relevant dimensions in the local dengue context. Their research reinforces the importance of considering behavioral determinants together rather than treating health knowledge as an isolated predictor of prevention.

Behavioral prevention should also be understood as a shared responsibility between individuals, households, and communities. When preventive practices are performed only occasionally, mosquito breeding sites may remain available despite periodic cleaning campaigns. Therefore, the continuity of household practices and neighborhood cooperation is essential.

From the PRECEDE–PROCEED perspective, predisposing factors influence willingness to undertake preventive activities, enabling factors determine whether these activities are practically achievable, and reinforcing factors help sustain them. For example, a household may understand the importance of cleaning water containers but may be unable to maintain the practice without adequate water-storage alternatives, appropriate cleaning materials, or regular encouragement from community health workers.

These relationships suggest that dengue prevention programs should emphasize practical behavioral competencies rather than information dissemination alone. Household demonstrations, community clean-up activities, regular health education, and supportive follow-up visits may help translate knowledge into more consistent preventive behavior. However, the effectiveness of such approaches in different Timor-Leste communities requires further context-specific evaluation.

4.4. Environmental Determinants and Household Practices

Environmental conditions strongly influence dengue transmission by creating *Aedes* mosquito breeding habitats. In Timor-Leste, uncovered water containers, stagnant water, inadequate drainage, and unmanaged waste contribute to environmental risks. Jeronimo (2017) identified potential breeding sites in many Dili households, despite generally favorable knowledge and attitudes. WHO (2022, 2025) recommends source reduction, proper waste disposal, and regular cleaning and covering of water-storage containers. However, prevention requires more than household responsibility. Adequate sanitation services, drainage, waste collection, and institutional coordination are essential enabling conditions for sustainable community-based dengue prevention.

4.5. Community Participation and Institutional Support

Community participation is essential for sustainable dengue prevention because vector control requires collective action. In Dili, Jeronimo (2017) identified inconsistencies in household breeding-site control, highlighting the need for stronger community engagement and health-provider support. Pacheco et al. (2025), studying 97 households, reported an association between health promotion and dengue prevention practices. Government initiatives in 2026 also involved household visits, community education, and university collaboration (Government of Timor-Leste, 2026). Within PRECEDE–PROCEED, institutional resources enable participation, while family support, community leadership, and health-worker encouragement reinforce sustained preventive behavior.

4.6. Nursing and Public Health Interventions

Nurses and community health workers play important roles in dengue prevention through health education, household visits, early risk identification, and community mobilization. They can

explain transmission, demonstrate preventive practices, identify breeding sites, and promote timely medical care. School-based education and collaboration with local leaders can further strengthen community awareness. In Timor-Leste, collaboration between health professionals and universities illustrates this approach (Government of Timor-Leste, 2026). Within PRECEDE–PROCEED, nursing interventions strengthen predisposing, enabling, and reinforcing factors. However, sustainable prevention also requires institutional support, adequate resources, and effective environmental services.

4.7. Overall Thematic Synthesis

The six themes demonstrate that community-based dengue prevention in Timor-Leste is influenced by interconnected behavioral, environmental, social, and institutional determinants. Epidemiological evidence establishes the continuing burden of dengue, while local studies indicate that favorable knowledge and attitudes may coexist with inconsistent preventive practices and persistent household breeding sites.

The thematic findings can be interpreted through the three principal behavioral categories of the PRECEDE–PROCEED Model. Predisposing factors include knowledge, attitudes, beliefs, and perceptions of dengue risk. Enabling factors include household resources, environmental infrastructure, sanitation services, access to health education, and practical opportunities for preventive action. Reinforcing factors include family support, community leadership, health professionals, educational institutions, and government commitment.

These determinants operate within broader environmental and organizational conditions that influence the sustainability of preventive practices. Consequently, improvements in community knowledge must be accompanied by accessible resources, supportive infrastructure, institutional coordination, and sustained social reinforcement.

The evidence also indicates that dengue prevention should not depend exclusively on periodic fumigation or emergency campaigns. Instead, prevention requires continuous household practices, collective environmental management, community engagement, and coordinated public health interventions. Such an approach provides a foundation for developing context-sensitive strategies that recognize the practical circumstances and institutional capacities of communities throughout Timor-Leste.

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5. DISCUSSION

5.1. Dengue Prevention Requires More Than Knowledge and Awareness

The findings of this narrative review indicate that dengue prevention in Timor-Leste should be understood as a multidimensional public health challenge rather than simply a matter of individual knowledge or awareness. Although health education remains essential, the available local evidence suggests that awareness does not always translate into consistent preventive practices. Jeronimo (2017), for example, identified a discrepancy between reported knowledge and attitudes and the implementation of household-level dengue prevention measures in Dili. This finding is important because it demonstrates that providing information alone may be insufficient to produce sustained behavioral change.

The PRECEDE–PROCEED Model provides a useful explanation for this gap. Knowledge, beliefs, perceived susceptibility, and attitudes are predisposing factors that may encourage individuals to adopt preventive behaviors. However, these factors operate alongside enabling conditions, such as access to waste collection, appropriate water-storage facilities, cleaning materials, and reliable health information. Reinforcing factors, including family encouragement, community leadership, health-worker follow-up, and neighborhood expectations, may further determine whether preventive behaviors are maintained over time (Green & Kreuter, 2005).

Consequently, dengue education in Timor-Leste should move beyond the delivery of general messages and focus on supporting households to translate knowledge into practical and regular action. Educational activities should demonstrate how to identify and eliminate mosquito breeding sites, how to cover and clean water-storage containers, and how to maintain environmental hygiene around homes. Such activities should be accompanied by practical assistance and follow-up rather than being limited to occasional awareness campaigns.

5.2. Environmental Conditions and the Limits of Individual Responsibility

The environmental dimension is particularly important in dengue prevention because *Aedes* mosquitoes breed in water-holding containers and other suitable environments around human settlements. The persistence of potential breeding sites cannot always be explained by individual negligence. Household water-storage practices, irregular waste collection, drainage

conditions, housing characteristics, and the availability of environmental sanitation services may influence the ability of residents to prevent mosquito breeding.

The local findings reported by Jeronimo (2017), including the presence of potential breeding sites in surveyed households, highlight the importance of examining the conditions in which preventive behavior occurs. These findings should not be interpreted as evidence that households alone are responsible for dengue transmission. Instead, they point to the interaction between household practices and the broader environmental and institutional conditions that shape those practices.

This interpretation is consistent with the ecological orientation of the PRECEDE–PROCEED Model. Health behavior is influenced not only by personal motivation but also by the physical and social environments in which people live. Porter (2016) emphasizes that the model supports population-centred and participatory health promotion, recognizing that healthier behavior requires conditions that enable people to protect their health.

For Timor-Leste, this means that community-based dengue prevention should be linked to municipal waste management, drainage improvement, access to water and sanitation services, and environmental monitoring. Households can be encouraged to cover water containers, remove discarded objects, and clean their surroundings regularly. However, these responsibilities should be supported by functioning public services and coordinated action by relevant institutions. A sustainable prevention strategy therefore requires shared responsibility between households, communities, health services, and local government.

5.3. Community Participation as a Foundation for Sustainable Prevention

Community participation is not merely an additional component of dengue prevention; it is central to the sustainability of vector-control activities. Residents possess practical knowledge of their neighborhoods, including common water-storage practices, local environmental problems, and locations where waste or stagnant water accumulates. This knowledge can strengthen prevention programmes when communities are actively involved in identifying problems, planning activities, and evaluating progress.

The World Health Organization (WHO, 2024) emphasizes the importance of risk communication and community engagement in dengue preparedness and response. Effective

engagement requires more than distributing information. It involves understanding local circumstances, listening to community concerns, identifying trusted communication channels, and developing prevention activities that are relevant and feasible in everyday life. WHO also highlights the importance of community ownership in sustaining vector-control practices (WHO, n.d.).

In Timor-Leste, community participation may be strengthened through collaboration among suco and aldeia leaders, health workers, schools, youth organizations, women's groups, religious institutions, and civil society organizations. Regular neighborhood clean-up activities, household visits, school-based education, and community discussions may provide practical opportunities for collective action. These activities should be designed as continuing processes rather than isolated campaigns conducted only during periods of increased dengue transmission.

Nevertheless, participation should be meaningful and inclusive. Community members should not be treated only as recipients of instructions or as unpaid implementers of government programmes. They should have opportunities to identify local priorities, contribute to decisions, and provide feedback on the accessibility and effectiveness of prevention activities. This participatory approach is consistent with the ethical and ecological principles of the PRECEDE–PROCEED Model (Porter, 2016).

5.4. The Role of Nurses and Community Health Workers

Nurses and community health workers can play an important role in connecting health services with households and local communities. Their contribution should extend beyond clinical care for patients with dengue to include health promotion, early recognition of warning signs, household education, community mobilization, and coordination with environmental and local-government sectors.

Within the PRECEDE–PROCEED framework, nurses can contribute to the assessment of predisposing, enabling, and reinforcing factors. At the household level, they can identify misunderstandings about dengue transmission, explore barriers to preventive practices, and provide practical demonstrations of source reduction. At the community level, they can work with local leaders and schools to organize education and environmental activities. At the health-

system level, they can communicate recurring environmental and behavioral problems to relevant authorities.

Health education should also address appropriate care-seeking behavior. Community members need to recognize that dengue can progress to severe disease and that timely assessment by health professionals is important when warning signs occur. Communication should be accurate, understandable, culturally appropriate, and delivered in languages accessible to the intended population. The WHO's dengue risk communication and community engagement toolkit provides a practical resource for planning such activities (WHO, 2024).

Importantly, nursing-led prevention should not become an isolated responsibility placed on individual health workers. Nurses require institutional support, adequate educational materials, opportunities for community outreach, and coordination mechanisms with other sectors. Their contribution is most effective when embedded in an integrated public health strategy.

5.5. Applying PRECEDE–PROCEED to Dengue Prevention in Timor-Leste

The findings suggest that the PRECEDE–PROCEED Model can provide a structured basis for designing and evaluating community-based dengue prevention in Timor-Leste. Its value lies in connecting the identification of health problems with the behavioral, environmental, educational, and organizational conditions that influence those problems.

At the PRECEDE stage, programme planners should begin by identifying community priorities and assessing the local dengue burden. This assessment should consider epidemiological information alongside residents' experiences, household practices, environmental conditions, and access to prevention resources. The analysis should then distinguish among predisposing, enabling, and reinforcing factors. For example, limited knowledge of breeding sites may represent a predisposing barrier; inadequate waste collection or insufficient water-container covers may represent enabling barriers; and the absence of regular encouragement or follow-up may represent a reinforcing barrier.

At the PROCEED stage, interventions should be implemented through coordinated health education, environmental management, community mobilization, and institutional collaboration. Evaluation should examine not only whether activities have been conducted but also whether they have improved the conditions and behaviors that support prevention. Process

indicators may include the continuity of household visits, participation in community activities, and implementation of environmental clean-up programmes. Impact indicators may include changes in knowledge, household preventive practices, and the presence of potential mosquito breeding sites. Longer-term outcome evaluation may examine trends in dengue morbidity and mortality, while recognizing that these outcomes are also influenced by climatic, epidemiological, and health-system factors.

The model should therefore be used as a planning and evaluation framework, not as evidence that a particular intervention will automatically reduce dengue incidence. Its effectiveness in the Timor-Leste context would need to be assessed through locally designed and appropriately evaluated programmes.

5.6. Policy and Public Health Implications

Several implications emerge from this review. First, dengue prevention should be integrated into routine primary health-care and community health-promotion activities rather than depending exclusively on emergency campaigns during outbreaks. Regular household engagement may help maintain preventive practices throughout the year.

Second, environmental management should be treated as a shared public responsibility. Health authorities, municipal services, educational institutions, and community organizations should coordinate their activities to address waste disposal, drainage, water storage, and the elimination of breeding sites in public and private spaces. The WHO (2022) guidance on dengue prevention in Timor-Leste emphasizes integrated vector management, including source reduction, environmental management, and community-led cleaning activities.

Third, health communication should be adapted to local social and cultural circumstances. Messages should be understandable, practical, and delivered through channels trusted by communities. The involvement of local leaders, teachers, nurses, youth groups, and religious organizations may help strengthen the credibility and continuity of prevention activities.

Fourth, programme evaluation should include behavioral and environmental indicators in addition to epidemiological outcomes. A reduction in dengue cases is an important public health objective, but it does not by itself explain whether a programme has strengthened community

knowledge, improved household practices, or developed sustainable local partnerships. The PRECEDE–PROCEED Model offers a way to connect these different levels of evaluation.

Finally, innovative vector-control approaches, including Wolbachia-based strategies where appropriate, may be considered as complementary components of integrated dengue prevention. However, such approaches should be assessed in relation to national policy, technical feasibility, community understanding, and local implementation capacity. They should not replace routine environmental management, community engagement, or established vector-control measures.

5.7. Strengths and Limitations of the Review

This review has several strengths. It applies an established health-promotion framework to a public health issue of direct relevance to Timor-Leste and brings together epidemiological, behavioral, environmental, and institutional perspectives. It also considers the practical roles of nurses, community health workers, local leaders, and public institutions in strengthening community-based dengue prevention.

However, the findings should be interpreted in light of several limitations. First, this is a narrative literature review rather than a systematic review. The literature identification process was targeted and iterative, and no claim is made that all relevant publications were identified. Second, the amount of locally published research on dengue-related knowledge, behavior, environmental conditions, and intervention outcomes in Timor-Leste remains limited. Some local evidence is based on individual studies conducted in Dili and may not represent conditions in rural municipalities or other communities.

Third, the available studies differ in design, population, geographical coverage, and outcome measures. Their findings therefore cannot be directly combined to estimate a national prevalence of preventive behaviors or the effectiveness of specific interventions. Fourth, recommendations derived from international guidance and the PRECEDE–PROCEED framework should be understood as context-informed proposals rather than interventions whose effectiveness has already been demonstrated throughout Timor-Leste.

Future research should include community-based studies across different municipalities, with attention to variations in water access, sanitation, housing, health-service availability, and local

participation. Implementation research could also assess whether interventions designed around predisposing, enabling, and reinforcing factors improve the consistency of household prevention practices and the sustainability of community vector-control activities.

5.8. Overall Interpretation

Taken together, the evidence suggests that sustainable dengue prevention in Timor-Leste requires an integrated approach that connects individual knowledge with household capacity, community participation, environmental conditions, and institutional support. The central implication of the PRECEDE–PROCEED Model is that preventive behavior cannot be understood or strengthened in isolation from the social and environmental conditions in which it occurs.

Accordingly, community-based dengue prevention should be developed as a continuing partnership among households, nurses, community health workers, local leaders, educational institutions, and government agencies. Such an approach offers a practical and theoretically grounded direction for strengthening health promotion and vector control in Timor-Leste.

6. CONCLUSION

Dengue prevention in Timor-Leste requires an integrated and sustained public health approach that addresses not only individual knowledge and awareness but also the behavioral, environmental, social, and institutional conditions that influence preventive practices. The evidence discussed in this review indicates that awareness alone does not necessarily lead to consistent household-level prevention. Effective dengue control therefore requires practical opportunities, adequate resources, continuous community engagement, and institutional support.

The PRECEDE–PROCEED Model provides a relevant framework for understanding these interconnected determinants and translating them into coordinated health-promotion strategies. By examining predisposing, enabling, and reinforcing factors, programme planners can identify why preventive behaviors are adopted, inconsistently practiced, or difficult to maintain. Its emphasis on implementation and evaluation also offers a structured approach to assessing whether community interventions produce meaningful behavioral, environmental, and public health improvements.

In Timor-Leste, community-based dengue prevention should strengthen collaboration among households, nurses, community health workers, suco and aldeia leaders, schools, municipal authorities, and other relevant institutions. Health education should be accompanied by practical household guidance, regular environmental management, accessible sanitation services, and opportunities for communities to participate in planning and evaluating local activities. Nurses and community health workers can serve as important links between health services and communities, particularly through household education, early recognition of warning signs, and coordination of preventive activities.

Nevertheless, the available local evidence remains limited and is concentrated largely in Dili. Further research is needed across different municipalities to examine variations in community knowledge, preventive practices, environmental conditions, access to health services, and programme implementation. Future intervention studies should also assess the feasibility and effectiveness of strategies designed around the predisposing, enabling, and reinforcing dimensions of the PRECEDE–PROCEED Model.

Ultimately, sustainable dengue prevention in Timor-Leste depends on recognizing that individual behavior is shaped by the conditions in which people live. A participatory, environmentally responsive, and institutionally supported approach offers a meaningful direction for strengthening community health promotion and dengue prevention. The PRECEDE–PROCEED Model can help guide this process, provided that its application is adapted to local priorities and evaluated through appropriate community-based evidence.

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