

Educational and Ecological Assessment of Factors Influencing Dengue Prevention in the Bahodopi Primary Health Center Working Area, Indonesia

ABSTRACT

Aims: This study aimed to analyse the predisposing, enabling, and reinforcing factors influencing dengue fever (DF) prevention among communities within the Bahodopi Primary Health Centre catchment area, Morowali Regency, Indonesia.

Participants and Methods: A qualitative study using a phenomenological design was conducted in June 2026. Participants were purposively selected until data saturation was achieved and included healthcare professionals and community members involved in dengue prevention. Data were collected through in-depth interviews, field observations, and document reviews, then analysed thematically based on the Educational and Ecological Assessment component of the PRECEDE-PROCEED Model.

Findings: Three categories of determinants influencing dengue prevention were identified: predisposing, enabling, and reinforcing factors. Predisposing factors showed that participants generally had adequate knowledge and positive attitudes towards dengue prevention, although preventive practices were not consistently implemented. Enabling factors included limited human resources, the absence of community-based *Jumantik* (larvae monitoring volunteer) cadres, and inadequate facilities and programme funding. Reinforcing factors comprised support from healthcare professionals, local government, community leaders, and multisectoral stakeholders, which strengthened larval surveillance, mosquito breeding site elimination, health education, and timely responses to dengue cases.

Conclusion: Dengue prevention within the Bahodopi Primary Health Centre catchment area is influenced by the interaction of predisposing, enabling, and reinforcing factors. Strengthening behaviour change communication, establishing *Jumantik* cadres, increasing resource support, and enhancing multisectoral collaboration are essential to improve the effectiveness and sustainability of dengue prevention programmes at the primary healthcare level.

Keywords : Dengue; Health Promotion; Health Behavior; Primary Health Care; Qualitative Research

Introduction

Health promotion is a fundamental strategy for disease prevention by empowering individuals and communities to improve and maintain their health. According to the World Health Organization (WHO), health promotion is implemented through advocacy, social support, and community empowerment ^[1]. One of the most widely applied frameworks for planning and evaluating health promotion programmes is the PRECEDE-PROCEED Model, which emphasises the assessment of predisposing, enabling, and reinforcing factors to guide the development of effective behavioural and environmental interventions ^[2].

Dengue fever (DF) remains a major global public health challenge, with its geographical distribution continuing to expand because of rapid urbanisation, climate change, and increased population mobility ^[3,4]. The increasing incidence and geographical spread of dengue may also be associated with changes in population density and distribution, urban development, population mobility, climate change, and other epidemiological factors that require further investigation ^[5]. Effective dengue prevention depends not only on vector control but also on sustained community participation through improved knowledge, behavioural change, and the consistent adoption of preventive practices ^[6]. In Indonesia, 88,593 dengue cases and 621 deaths were reported by 30 April 2024, representing almost a threefold increase compared with the same period in the previous year ^[7].

In Central Sulawesi Province, the dengue incidence rate (IR) remained high at 58.40 per 100,000 population in 2023, substantially exceeding the national target of ≤ 10 per 100,000 population. Morowali Regency recorded one of the highest dengue burdens, with 183 cases (IR: 99.3 per 100,000 population) in 2023 ^[8]. Within the regency, the Bahodopi Primary Health Centre catchment area has consistently reported the highest number of dengue cases since 2019, increasing to 302 cases in 2024 and remaining high with 158 cases in 2025 ^[8]. These findings indicate that Bahodopi continues to experience a substantial dengue burden despite ongoing control efforts.

The Indonesian government has implemented several dengue prevention strategies, including the *Pemberantasan Sarang Nyamuk* (PSN) Plus programme, the One House One Larvae Monitor (1R1J) initiative, epidemiological investigations, and insecticide fogging. However, the effectiveness of these interventions largely depends on community knowledge, attitudes, and active participation [9]. A community empowerment study in Sidrap Regency demonstrated that strengthening community participation through an independent larva monitoring model and the use of simple ovitraps improved dengue-related preventive behaviours and could support dengue prevention and control at the community level [10]. Preliminary observations indicated that many community members still perceived fogging as the primary preventive measure, whereas routine source reduction through PSN had not yet become a consistent practice.

Previous international studies applying the PRECEDE-PROCEED Model have demonstrated that dengue prevention is influenced by the interaction of predisposing, enabling, and reinforcing factors [11]. Specifically, inadequate community knowledge of dengue and its clinical manifestations [12,13] limited access to preventive resources and larvicides such as temephos [14], and insufficient support from family members, community leaders, and the surrounding social environment [14,15,16] have been identified as major barriers to effective dengue prevention. Despite this growing body of evidence, studies integrating the three components of the Educational and Ecological Assessment within Indonesian communities, particularly in high-incidence settings, remain limited.

Therefore, this study aimed to analyse the predisposing, enabling, and reinforcing factors influencing dengue prevention among communities within the Bahodopi Primary Health Centre catchment area, Morowali Regency, Indonesia, using the Educational and Ecological Assessment component of the PRECEDE-PROCEED Model.

Participants And Methods

Study Design and Setting

This study employed a qualitative phenomenological design to explore the experiences, perceptions, and barriers encountered by community members and healthcare professionals regarding dengue fever (DF) prevention. The study focused on the Educational and Ecological Assessment component of the PRECEDE-PROCEED Model, which examines predisposing, enabling, and reinforcing factors influencing health-related behaviours. A phenomenological approach was selected to provide an in-depth understanding of participants' lived experiences and perspectives related to dengue prevention. The study was conducted in June 2026 within the Bahodopi Primary Health Centre catchment area, Morowali Regency, Central Sulawesi Province, Indonesia. The study site was purposively selected because it has consistently reported the highest dengue incidence in Morowali Regency over recent years, making it a priority area for dengue prevention and control.

Participants

Participants were recruited using purposive sampling to obtain information-rich cases relevant to the study objectives. The participants comprised healthcare professionals involved in the dengue control programme, including the Head of the Primary Health Centre, the health promotion programme coordinator, and other relevant staff, as well as community members residing within the Bahodopi Primary Health Centre catchment area. Eligible participants were those willing to participate, able to communicate effectively, and had experience or involvement in dengue prevention activities. Participant recruitment continued until data saturation was achieved, with no new themes emerging from subsequent interviews.

As this was a qualitative phenomenological study, sample size was not determined using a statistical formula but was guided by the principle of information power and data saturation. In line with methodological guidance indicating that samples of six to twelve knowledgeable, information-rich participants are typically sufficient to reach saturation in homogeneous, tightly-scoped qualitative inquiries [17,18], recruitment continued until interviews with successive informants yielded no new codes or subthemes relevant to the predisposing, enabling, and reinforcing components of the Educational and Ecological Assessment. Saturation was judged to have been reached after the sixth interview, when two consecutive interviews (I5 and I6) produced no additional codes; this was confirmed through ongoing comparison of transcripts during data collection and through researcher discussions.

Sampling followed a two-stage purposive (criterion-based) procedure. First, two key informants (the Head of the Bahodopi Primary Health Centre and the dengue control programme coordinator) were selected deliberately because of their programmatic authority and first-hand oversight of dengue prevention activities. Second, four supporting informants were selected from community members

residing within the Bahodopi Primary Health Centre catchment area, identified with the assistance of the key informants and village contacts and screened against the eligibility criteria described above (willingness to participate, ability to communicate effectively, and direct experience with dengue prevention activities); informants were drawn from different villages within the catchment area to capture a range of household-level experiences. A total of six informants (two key informants and four supporting informants) were interviewed, consistent with the sample size reported in Table 2.

Data Collection

Data were collected through methodological triangulation using in-depth interviews, field observations, and document reviews. Face-to-face semi-structured interviews were conducted using an interview guide and audio-recorded with participants' informed consent to explore their experiences and perceptions regarding the predisposing, enabling, and reinforcing factors influencing dengue prevention. Field observations were undertaken to assess environmental conditions, community practices, and vector control activities, with photographs used to support field documentation. In addition, relevant documents, including health profiles, dengue surveillance reports, population statistics, and dengue control programme records obtained from the Bahodopi Primary Health Centre and the Morowali District Health Office, were reviewed to strengthen data interpretation.

Data Analysis

Data were analysed using thematic analysis. All interviews were transcribed verbatim and systematically coded to identify recurring patterns and themes. The identified themes were subsequently organised according to the Educational and Ecological Assessment component of the PRECEDE-PROCEED Model, encompassing predisposing, enabling, and reinforcing factors. The trustworthiness of the findings was enhanced through source and methodological triangulation, researcher discussions to refine data interpretation, and member checking with selected participants to ensure that the findings accurately reflected their experiences and perspectives.

Coding was conducted manually in a structured codebook. Each transcript, field-observation note, and reviewed document was read line-by-line to generate open (primary) codes describing discrete units of meaning. This process yielded 71 primary codes across the dataset. Primary codes were then iteratively compared, merged, and grouped through axial coding into 23 categories (subthemes), which were subsequently synthesised into four overarching themes: predisposing factors, enabling factors, and reinforcing factors, corresponding to the Educational and Ecological Assessment component of the PRECEDE-PROCEED Model, together with a fourth cross-cutting theme describing the sequential stages through which dengue prevention was implemented. Coding decisions were cross-checked between researchers, and any discrepancies were resolved through discussion until consensus was reached. The resulting coding framework, showing how primary codes were categorised into subthemes and themes, is presented in Table 1. The complete, traceable coding framework for all 71 primary codes — including an illustrative excerpt and informant attribution for each code — is provided in Supplementary Table S1.

Table 1. Categorisation of Primary Codes into Subthemes and Themes

Primary codes are listed in condensed form for readability; full descriptive code labels, verbatim illustrative excerpts, and informant attribution (I1–I6) for each of the 71 codes are provided in Supplementary Table S1.

Theme	Category (Subtheme)	Primary Codes	n
Predisposing Factors	Knowledge	3M Plus education delivered; Education via epidemiological investigation; Info via socialisation, PSN, fogging; No dedicated outreach since 2024; No Jumantik cadre for outreach; Fogging/Abate as main info source.	6
	Perceptions	Waste/sanitation seen as DBD cause; Low awareness undermines PSN; Abate misperceived as sales scheme; Positive view of fogging/Abate/surveillance; Desire for routine (not reactive) action.	5

Theme	Category (Subtheme)	Primary Codes	n
	Awareness	Weekly clean-up (Jumat Bersih); Leaders build community receptiveness; Awareness inconsistent despite PSN; Officer visits motivate clean-up; Desire for continuous engagement.	5
	Attitudes	Participation varies by village; Mixed acceptance vs. distrust; Refusal from prior Abate scam; Openness to fogging/Abate; Proposal for Jumantik cadre.	5
Reinforcing Factors	Healthcare Professional Support	Cross-programme case response; Routine surveys, criterion-based fogging; Officer presence builds security.	3
	Multisectoral Collaboration	Joint govt/Health Office coordination; PSN via cross-sector cooperation.	2
	Village and Subdistrict Government Support	Case reports mobilise clean-up; Village officials ease participation.	2
	Community Leader Support	Leaders engaged in messaging; Leaders increase programme trust.	2
	Community Support	Willingness to support activities; Refusal from limited understanding.	2
Enabling Factors	Human Resources	Cross-programme staffing; Staff shortage vs. 12 villages; No formal Jumantik cadre.	3
	Facilities and Infrastructure	In-clinic educational media available; Insufficient field equipment.	2
	Programme Funding	BOK-funded PSN schedule; Insufficient funding for outreach.	2
	Health Information and Educational Media	In-clinic pamphlets/audiovisual media; Limited outreach media use.	2
	Coordination Systems	Multi-tier case coordination; Coordination enables prompt follow-up.	2
	Implementation Barriers	Combined staff/budget/equipment shortage; No cadre as structural barrier; Waste/stagnant water as barrier; Community distrust of officers.	4
Stages of Dengue Prevention	Case Identification and Confirmation	Case confirmed before response; Prompt follow-up of positive cases.	2
	Epidemiological Investigation	Collaborative field investigation; Prompt investigation pre-empts cases.	2
	Larval Surveillance	Larval survey guides PSN; Survey results guide escalation.	2
	Mosquito Breeding Site Elimination (PSN)	3M Plus as PSN principle; Scheduled PSN via BOK; Cross-sector weekly clean-up; Repeated PSN due to low awareness.	4
	Health Education and Promotion	Field education post-investigation; In-clinic print/AV media; No dedicated session since 2024; Community requests more education.	4
	Targeted Fogging	Fogging triggered by case count; Fogging follows PE and PSN; Fogging insufficient without hygiene.	3
	Monitoring and Evaluation	Repeat visits track case trends; Priority villages from case patterns; Post-fogging follow-up visits.	3

Theme	Category (Subtheme)	Primary Codes	n
	Community Empowerment	Weekly clean-up via subdistrict govt; Leaders strengthen message uptake; No cadre limits monitoring; Variable resident trust/participation.	4
Total	23 categories	4 themes / 71 primary codes	71

Findings

Informant Characteristics

Six informants were purposively recruited for this study, comprising two key informants—the Head of Bahodopi Primary Health Centre and the dengue control programme coordinator—and four supporting informants who were community members residing within the Bahodopi Primary Health Centre catchment area, Morowali Regency, Indonesia. All informants had relevant experience and were actively involved in the implementation or practice of dengue prevention activities. The characteristics of the informants are presented in **Table 2**.

Table 2. Characteristics of Informants

Informant ID	Age (years)	Education	Occupation / Position	Place of Residence	Informant Type
I1	51	Bachelor's degree	Head of Bahodopi Primary Health Centre	Bahodopi Village	Key Informant
I2	30	Diploma III	Dengue Control Programme Coordinator	Bahodopi Village	Key Informant
I3	29	Bachelor's degree	Homemaker	Bahomakmur Village	Supporting Informants
I4	37	Senior School	High Homemaker	Bahodopi Village	Supporting Informants
I5	42	Senior School	High Self-employed	Labota Village	Supporting Informants
I6	34	Junior School	High Homemaker	Keurea Village	Supporting Informant

Predisposing Factors

Thematic analysis revealed that predisposing factors were the most influential determinants of dengue fever (DF) prevention behaviours within the Bahodopi Primary Health Centre catchment area. Four subthemes emerged: knowledge, perceptions, awareness, and attitudes towards dengue prevention.

Community knowledge of dengue was generally adequate. All informants reported that residents had received health education on dengue prevention through health promotion activities, community outreach, implementation of the 3M Plus strategy, larval surveillance, distribution of temephos (Abate®) larvicide, and insecticide fogging. The Head of the Primary Health Centre emphasised that education on the 3M Plus strategy remains a key component of dengue prevention because it is practical and can be readily adopted by community members.

"...The main preventive measures include the 3M Plus strategy: draining water storage containers, covering water containers, disposing of unused items that can collect water, and, in addition, using mosquito nets and mosquito repellents..." (I1)

However, the dengue control programme coordinator explained that the last dedicated health education session was conducted in 2024. Since then, educational activities have primarily been integrated into mosquito breeding site elimination (*Pemberantasan Sarang Nyamuk* [PSN]) programmes and multisectoral collaboration. Furthermore, the absence of community-based

Jumantik (larvae monitoring volunteer) cadres has limited the dissemination of information, leaving health professionals as the primary source of community education.

Community perceptions regarding dengue risk were generally appropriate. Informants recognised that unmanaged waste, stagnant water, and poor environmental sanitation increase the risk of *Aedes aegypti* breeding. Nevertheless, misconceptions regarding the distribution of temephos larvicide were still evident, as some residents believed that health workers were attempting to sell the product.

"...When health workers came to distribute Abate®, some people thought they were selling it, so they refused because they assumed they would have to pay for it..." (I2)

Community awareness of environmental cleanliness has gradually improved through community clean-up campaigns, PSN activities, and collaboration involving village authorities, subdistrict officials, religious leaders, community leaders, and youth representatives. Despite these efforts, all informants acknowledged that awareness remained inconsistent, as household waste, uncovered water storage containers, and stagnant water were still commonly observed, creating potential mosquito breeding sites.

"...We carry out mosquito breeding site elimination activities, but community awareness is still lacking..." (I2)

Community attitudes towards dengue prevention programmes were generally positive. Residents welcomed fogging, larval surveillance, and temephos distribution as important measures to reduce dengue transmission. However, some participants suggested that health education activities should be conducted more regularly and recommended establishing *Jumantik* cadres to encourage greater community participation.

"...The community responded positively because there is a lot of scattered waste here, and these activities can help reduce dengue transmission..." (I3)

Overall, the findings indicate that community knowledge, perceptions, awareness, and attitudes generally support dengue prevention efforts. Nevertheless, these positive attributes have not been consistently translated into preventive practices. The main barriers identified were limited health education activities, the absence of *Jumantik* cadres, and varying levels of community trust in public health programmes.

Reinforcing Factors

Thematic analysis identified five subthemes of reinforcing factors influencing dengue prevention behaviours within the Bahodopi Primary Health Centre catchment area: healthcare professional support, multisectoral collaboration, village and subdistrict government support, community leader support, and community support.

Healthcare professionals played a central reinforcing role by conducting epidemiological investigations, larval surveillance, mosquito breeding site elimination (PSN), health education, distribution of temephos larvicide, and insecticide fogging. These activities not only aimed to control dengue cases but also encouraged community participation in dengue prevention.

"...Whenever a dengue case is reported, we implement cross-programme collaboration. The surveillance team conducts an epidemiological investigation, while the health promotion team provides health education to all residents in the affected village..." (I1)

The success of dengue prevention programmes was further strengthened through multisectoral collaboration involving the District Health Office, subdistrict authorities, and village governments. This collaboration facilitated larval surveillance, PSN implementation, fogging operations, and community mobilisation for environmental clean-up campaigns.

"...We coordinate with the subdistrict government, village authorities, and the District Health Office to conduct larval surveillance, mosquito breeding site elimination, and fogging together..." (I1)

Village and subdistrict governments contributed by mobilising residents to participate in environmental sanitation activities and disseminating information on dengue prevention. Religious leaders, community leaders, women's representatives, and youth leaders were also actively engaged to enhance community acceptance of health messages.

"...We strengthen collaboration with religious leaders, women's groups, and youth leaders so that health messages are more readily accepted by the community..." (I1)

Most community members expressed positive support for fogging, temephos distribution, larval inspections, and community clean-up activities because they believed these interventions effectively reduced the risk of dengue transmission. However, some residents remained sceptical of visits from healthcare workers, resulting in less than optimal community participation.

"...Some people welcomed us, but others were still reluctant to trust us when we visited their neighbourhood..." (I2)

Overall, the findings demonstrate that reinforcing factors for dengue prevention arise from the collective support of healthcare professionals, government agencies, multisectoral partners, community leaders, and community members. Although collaborative efforts have been well established, strengthening health communication, enhancing multisectoral coordination, and promoting community empowerment remain essential to sustain active community participation in dengue prevention.

Enabling Factors

Thematic analysis identified several enabling factors influencing the implementation of dengue fever (DF) prevention programmes within the Bahodopi Primary Health Centre catchment area. These included the availability of human resources, facilities and infrastructure, programme funding, health information and educational media, coordination systems, and implementation barriers.

The availability of human resources was identified as a key factor supporting programme implementation. Dengue prevention and control activities involved multidisciplinary collaboration among the Head of the Primary Health Centre, surveillance officers, the dengue control programme coordinator, health promotion officers, sanitarians, and village midwives. However, the number of healthcare personnel remained insufficient to cover all 12 villages within the catchment area, and the programme was not yet supported by community-based *Jumantik* (larvae monitoring volunteer) cadres.

"...Whenever a dengue case is reported, we collaborate across programmes by coordinating with the surveillance team and health promotion officers to conduct epidemiological investigations in the field..." (I1)

Facilities and infrastructure generally supported programme implementation through the provision of educational materials, temephos (Abate®) larvicide, and operational equipment. Nevertheless, several essential field resources remained inadequate, limiting the effectiveness of programme activities.

"...We still lack sufficient equipment..." (I2)

Programme funding was primarily derived from the Health Operational Assistance Fund (Bantuan Operasional Kesehatan [BOK]), which supported mosquito breeding site elimination (Pemberantasan Sarang Nyamuk [PSN]), larval surveillance, and other field activities. However, limited financial resources constrained several health promotion initiatives, including routine community education and the establishment of *Jumantik* cadres.

"...PSN activities are included in the BOK schedule, but the funding is still insufficient..." (I2)

Health information and educational media were delivered through pamphlets and educational videos displayed at the Primary Health Centre to improve community knowledge of dengue prevention. However, the use of educational media at the community level remained suboptimal because face-to-face health education sessions were no longer conducted routinely.

Programme coordination was facilitated through collaboration among the Primary Health Centre, hospitals, the District Health Office, village governments, and subdistrict authorities. This coordination enabled every reported dengue case to be followed up promptly through epidemiological investigations, larval surveillance, PSN activities, and targeted fogging when epidemiological criteria were met.

"...Cases reported by hospitals are confirmed with the Primary Health Centre. We then conduct larval surveillance and mosquito breeding site elimination, and if transmission risk increases, we coordinate with the District Health Office to implement fogging..." (I1)

Despite these enabling resources, several implementation barriers remained. These included shortages of healthcare personnel, inadequate operational resources and funding, the absence of *Jumantik* cadres, and limited community participation resulting from poor environmental conditions characterised by unmanaged waste and stagnant water, as well as persistent mistrust of healthcare workers among some residents.

"...Some people welcomed us, while others were still reluctant to trust us when we visited..." (I2)

Overall, the findings indicate that enabling factors have supported the implementation of dengue prevention programmes; however, they have not yet been fully optimised. Strengthening human resource capacity, establishing community-based *Jumantik* cadres, increasing financial and

logistical support, and expanding community health education are essential to improve the effectiveness of dengue prevention programmes.

Stages of Dengue Prevention Based on Predisposing, Enabling, and Reinforcing Factors

Figure 1 summarises the thematic findings on dengue prevention based on the Educational and Ecological Assessment component of the PRECEDE-PROCEED Model. Informants described dengue prevention as a sequential process beginning with case identification and confirmation, followed by epidemiological investigation, larval surveillance, mosquito breeding site elimination (*Pemberantasan Sarang Nyamuk* [PSN]), health education, targeted fogging when epidemiological criteria were met, monitoring and evaluation, and community empowerment. These activities were implemented through collaboration between the Primary Health Centre, the District Health Office, village and subdistrict governments, and community members.

According to the interviews, epidemiological investigation and larval surveillance formed the basis for determining subsequent interventions. PSN was consistently identified as the primary dengue prevention strategy because it directly reduced mosquito breeding sites, whereas targeted fogging was considered a complementary intervention implemented only when epidemiological investigations indicated an increased risk of dengue transmission.

The thematic analysis further demonstrated that the implementation of each prevention stage was influenced by three groups of determinants identified in the PRECEDE-PROCEED Model. Predisposing factors included community knowledge, perceptions, awareness, and attitudes towards dengue prevention. Enabling factors comprised the availability of human resources, facilities and infrastructure, programme funding, educational media, and coordination systems. Reinforcing factors involved support from healthcare professionals, government agencies, multisectoral partners, community leaders, and community participation. Together, these findings illustrate that dengue prevention was shaped by behavioural, environmental, and organisational determinants identified through participants' experiences.

Eight sequential stages of dengue prevention were identified from the interviews: case identification and confirmation, epidemiological investigation, larval surveillance, mosquito breeding site elimination (PSN), health education and promotion, targeted fogging, monitoring and evaluation, and community empowerment. Illustrative accounts for each stage are presented below.

Case Identification and Confirmation.

Reported cases were first confirmed against the patient's identity, address, and location before any field response was initiated.

"...Cases of dengue fever are obtained from examinations at the Bahodopi Primary Health Centre or found at Morowali Hospital, and are then reconfirmed within the catchment area of the Primary Health Centre itself..." (I1)

Epidemiological Investigation.

Confirmed cases triggered a cross-programme response combining surveillance and health promotion staff.

"...Whenever a dengue case is reported, we collaborate across the dengue programme, contacting the surveillance team and then health promotion to carry out an epidemiological investigation in the field..." (I1)

Larval Surveillance.

Larval inspections at the case household and surrounding homes determined whether breeding sites were present and guided the next intervention.

"...After that, our task is to go to the field to carry out larval surveillance. Once a mosquito breeding site is found, especially for dengue, mosquito breeding site elimination is carried out..." (I1)

Mosquito Breeding Site Elimination (PSN).

PSN, grounded in the 3M Plus strategy, was described as the most frequently implemented and prioritised intervention, supported by a scheduled funding stream.

"...The measures taken are the 3M Plus strategy — draining water containers, covering water containers, and burying used items found around residential areas. In addition, the 'plus' component involves using mosquito nets and repellents to avoid mosquito bites..." (I1)

"...PSN already has a schedule through the Health Operational Assistance Fund (BOK) activities..." (I2)

Health Education and Promotion.

Health education was delivered alongside field investigations, although dedicated sessions had not been conducted routinely since 2024 and community members expressed a wish for more frequent contact.

"...The health promotion team educates the entire community in that village after the epidemiological investigation has been carried out..." (I1)

"...The last health education session was in 2024. Since then there hasn't been a dedicated education programme — now it is mostly delivered through PSN and cross-sector cooperation..." (I2)

"...If possible, there should be more frequent health education sessions so the community keeps being reminded. Sometimes if no one comes to remind us, people start to forget to clean their surroundings..." (I5)

Targeted Fogging.

Fogging was consistently framed as a complementary, criterion-triggered measure rather than the primary strategy, with informants aware that its effect on adult mosquitoes did not remove breeding sites.

"...If the number of cases in that catchment area is high, we coordinate with the District Health Office to carry out fogging. That is what we have been doing..." (I1)

"...Fogging is good because it reduces the mosquitoes, but if the environment is still dirty the mosquitoes will come back again..." (I6)

Monitoring and Evaluation.

Follow-up visits and continued coordination with village and subdistrict governments allowed the Primary Health Centre to track case trends and confirm that preventive behaviours were sustained after fogging or PSN.

"...We continue coordinating with the subdistrict and village governments. If cases increase, we go out again to carry out larval surveillance and PSN, and if the criteria are met, fogging..." (I1)

"...Usually after fogging, they still come back to check the surroundings, asking whether anyone else is sick..." (I5)

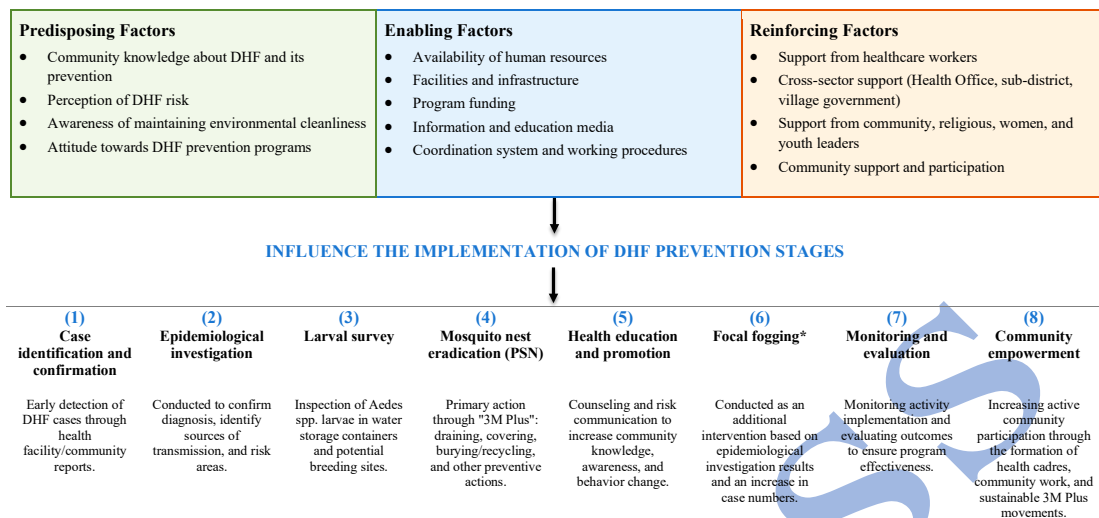
Community Empowerment.

Community empowerment was pursued through scheduled clean-up activities coordinated with village governments and community leaders, although the absence of Jumantik cadres continued to limit the extent to which this responsibility was shared with the community itself.

"...We invite the community to carry out mosquito breeding site elimination regularly. We convey this through the subdistrict government so that the community carries out community clean-up every Friday in each village..." (I1)

"...The response is good, because there is a lot of rubbish scattered around here. So when officers come to clean the environment or carry out fogging, we are happy because it can reduce the mosquitoes..." (I3)

Factors Influencing DHF Prevention (PRECEDE-PROCEED Model)



*Focal fogging is implemented if necessary based on epidemiological investigation results and an increase in case numbers.

Figure 1. Stages of Dengue Prevention Identified from the Educational and Ecological Assessment Based on the PRECEDE–PROCEED Model

Discussion

This study demonstrates that dengue fever (DF) prevention behaviours within the Bahodopi Primary Health Centre catchment area cannot be explained solely by biological aspects of vector control but rather by the interaction of predisposing, enabling, and reinforcing factors, as conceptualised in the Educational and Ecological Assessment component of the PRECEDE–PROCEED Model. These findings highlight that effective dengue prevention depends on a balance between individual capacity, supportive environments, and health system capacity. Previous systematic reviews and meta-analyses have similarly identified the PRECEDE–PROCEED Model as one of the most effective health promotion frameworks for improving health knowledge and behaviours through the integration of these three components [19,20], and its applicability has also been demonstrated in studies of vector-borne disease prevention [21,22].

Regarding predisposing factors, this study found that community members generally possessed adequate knowledge of dengue, particularly concerning disease transmission, the 3M Plus strategy, and the importance of maintaining environmental cleanliness. Nevertheless, this knowledge was not consistently translated into preventive practices, as household waste, uncovered water storage containers, and stagnant water remained common and continued to provide breeding sites for *Aedes aegypti*. These findings are consistent with the systematic review by Arham et al., which reported that although communities across Asia generally demonstrate good knowledge and positive attitudes towards dengue, household-level preventive practices remain suboptimal [22]. Similar findings have been reported in Cambodia, where high levels of knowledge did not necessarily correspond to effective vector control practices [23]. These observations suggest that improving knowledge alone is insufficient to produce sustained behavioural change without continuous behaviour change communication (BCC) strategies. This interpretation is supported by a recent meta-analysis showing that PRECEDE–PROCEED-based interventions consistently improve community knowledge, whereas sustained behavioural change requires complementary enabling and reinforcing factors [19]. Likewise, intervention studies have demonstrated that improvements in preventive behaviours are more likely when health education is combined with interventions addressing enabling and reinforcing determinants simultaneously [24].

The inconsistent relationship between knowledge and preventive practices reported in Indonesia [25], Malaysia [26], and several other Asian countries [22,23] further indicates that increased knowledge does not necessarily result in behavioural change. Such variation may be influenced by social norms, environmental conditions, access to resources, and the intensity of health communication. These findings imply that health education alone is unlikely to produce meaningful behavioural changes

unless communication strategies are tailored to the local social context. Previous studies on Behaviour Change Communication (BCC) in dengue prevention have demonstrated that sustained communication interventions are more effective in improving attitudes and preventive practices than one-way information dissemination [27,28]. Therefore, health education should be considered one component of a comprehensive dengue prevention strategy rather than a stand-alone intervention. An important finding of this study was the presence of misconceptions regarding the distribution of temephos (Abate®) larvicide. Some participants believed that healthcare workers were attempting to sell the product, leading to rejection of home visits. In addition, some community members continued to perceive insecticide fogging as the primary strategy for dengue prevention. These findings suggest persistent gaps in community understanding of public health interventions. Notably, the misconception that health workers distribute temephos for commercial purposes has rarely been reported in previous studies and represents a novel finding. This misconception reflects a communication gap between programme implementers and community members that may reduce acceptance of vector control interventions. Similar findings have been reported in studies showing that communities relying primarily on fogging or larviciding often develop a false sense of security, resulting in reduced participation in mosquito breeding site elimination [29]. Consequently, health education should emphasise that fogging targets only adult mosquitoes and does not eliminate breeding sites, making the 3M Plus strategy the cornerstone of dengue prevention. These findings are further supported by qualitative research in Indonesia demonstrating that misconceptions regarding dengue severity, mosquito breeding sites, and vector control measures constitute major barriers to preventive behaviours. Therefore, Social and Behaviour Change Communication (SBCC) strategies should focus not only on improving knowledge but also on correcting community perceptions and misconceptions [30].

With respect to enabling factors, this study found that dengue prevention programmes in Bahodopi were supported by cross-programme coordination, educational media, funding from the Health Operational Assistance Fund (Bantuan Operasional Kesehatan [BOK]), and an effective case referral and reporting system. However, programme effectiveness remained constrained by shortages of healthcare personnel, the absence of community-based *Jumantik* (larvae monitoring volunteer) cadres, inadequate operational resources, and limited funding for health promotion activities. These findings are consistent with a recent scoping review identifying shortages of human resources, logistics, and financial support as major barriers to implementing community-based dengue control programmes in low- and middle-income countries [31]. This suggests that strengthening dengue prevention programmes requires not only supportive policies but also sustained investment in human resources, operational infrastructure, and programme financing. Similar evidence indicates that community-based disease prevention programmes achieve greater behavioural impact when enabling factors, including adequate resources, supportive environments, and appropriate infrastructure, are available [26]. Furthermore, a recent systematic review highlighted educational materials, implementation support, and continuous programme monitoring as essential components of successful PRECEDE-PROCEED interventions [20].

The absence of *Jumantik* cadres emerged as one of the most important findings of this study because larval surveillance and community education remained heavily dependent on Primary Health Centre staff. This reliance is particularly challenging given that the Bahodopi Primary Health Centre serves twelve villages with a limited healthcare workforce. Consequently, the lack of community-based *Jumantik* cadres substantially restricts the coverage of household larval surveillance and health education. Community volunteers not only extend programme reach but also strengthen community ownership of dengue prevention initiatives, consistent with recommendations from co-creation approaches and the PRECEDE-PROCEED framework [20,32].

Limited programme funding, which has resulted in the discontinuation of routine face-to-face health education since 2024, further indicates that sustaining health promotion activities remains a major challenge. Although educational materials, including pamphlets and videos, are available at the Primary Health Centre, the dissemination of health information beyond healthcare facilities has become less effective. These findings are consistent with previous studies showing that financial constraints often lead to reductions in health promotion activities, despite continuous community education being essential for maintaining long-term preventive behaviours [31].

Regarding reinforcing factors, this study found that dengue prevention was supported by healthcare professionals, village and subdistrict governments, the District Health Office, religious leaders, community leaders, women's groups, and youth representatives. This support was reflected in

multisectoral coordination, community clean-up campaigns, epidemiological investigations, larval surveillance, and the delivery of health education messages. These findings support the World Health Organization's recommendation that effective vector control requires multisectoral collaboration and the active involvement of local governments and communities in environmental management [21]. The collaborative network established in Bahodopi represents an important form of social capital that strengthens the implementation of dengue prevention programmes. This finding is also consistent with previous studies demonstrating that reinforcing factors, including social support, family involvement, and community participation, significantly improve preventive behaviours following PRECEDE-PROCEED-based interventions [24].

Despite these collaborative efforts, community participation was not uniformly achieved. Some community members remained reluctant to engage with healthcare workers, limiting the coverage of health education activities and larval surveillance. This finding suggests that social support has not yet fully translated into trust in public health programmes. Previous research similarly indicates that the success of community-based interventions depends largely on public trust in implementing institutions [32]. Therefore, strengthening risk communication and promoting greater community involvement throughout all stages of programme implementation are essential for fostering stronger relationships between communities and health programme providers. The application of Behaviour Change Communication (BCC) and Social and Behaviour Change Communication (SBCC) strategies that actively engage community members has been shown to increase programme acceptance, strengthen preventive practices, and sustain long-term behavioural change in the control of vector-borne diseases [27,28,30].

This study also demonstrated that dengue prevention in Bahodopi has been implemented through a systematic sequence of activities, including case identification, epidemiological investigation, larval surveillance, mosquito breeding site elimination (*Pemberantasan Sarang Nyamuk* [PSN]), health education, targeted fogging, monitoring and evaluation, and community empowerment. These activities are conducted sequentially, with epidemiological investigations and larval surveillance serving as the basis for determining subsequent interventions. PSN is prioritised as the primary dengue prevention strategy, whereas targeted fogging is implemented only when epidemiological criteria are met. This approach is supported by a recent systematic review concluding that evidence for the effectiveness of space spraying (fogging) in reducing dengue transmission remains limited, whereas source reduction through PSN has stronger evidence as a sustainable long-term vector control strategy [33]. Accordingly, the Bahodopi Primary Health Centre's policy of prioritising PSN over routine fogging is consistent with current evidence-based recommendations. However, its success ultimately depends on sustained community participation in maintaining environmental cleanliness and eliminating mosquito breeding sites.

Overall, the findings of this study suggest that dengue prevention in endemic areas requires a comprehensive approach that extends beyond vector control to address behavioural determinants through PRECEDE-PROCEED-based health promotion interventions. In the Bahodopi context, programme priorities should include establishing community-based *Jumantik* (larvae monitoring volunteer) cadres, strengthening continuous behaviour change communication, enhancing human and financial resource capacity, and optimising multisectoral collaboration. Such an integrated approach is likely to achieve more sustainable improvements in dengue prevention than interventions focused solely on responding to reported cases.

Limitations

This study has several limitations. First, it was conducted within the catchment area of a single Primary Health Centre; therefore, the transferability of the findings to other settings with different demographic, social, and healthcare characteristics should be interpreted with caution. Second, the relatively small number of informants reflects experiences and perceptions within a specific local context, which may not represent broader community perspectives. Nevertheless, the credibility and trustworthiness of the findings were enhanced through source and methodological triangulation, as well as thematic analysis guided by the PRECEDE-PROCEED Model. Future studies should include multiple study sites and adopt mixed-methods approaches that integrate qualitative and quantitative data to provide a more comprehensive evaluation of the effectiveness of dengue prevention interventions.

Conclusion

This study demonstrates that dengue fever (DF) prevention within the Bahodopi Primary Health Centre catchment area is shaped by the interaction of predisposing, enabling, and reinforcing factors,

as conceptualised in the PRECEDE-PROCEED Model. Although community members generally possessed adequate knowledge and positive attitudes towards dengue prevention, preventive behaviours were not consistently practised. Programme effectiveness was further constrained by shortages of healthcare personnel, the absence of community-based *Jumantik* (larvae monitoring volunteer) cadres, limited operational resources and funding, and suboptimal community participation.

These findings highlight that effective dengue prevention requires an integrated approach that extends beyond vector control to encompass behaviour change, community empowerment, and health system strengthening. Prioritising continuous health education, establishing *Jumantik* cadres, strengthening human and financial resource capacity, and enhancing multisectoral collaboration are essential to improve the effectiveness and sustainability of dengue prevention programmes. Furthermore, these findings support the application of the PRECEDE-PROCEED Model as a practical and context-sensitive framework for designing, implementing, and evaluating dengue prevention strategies in primary healthcare settings.

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