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# School-based health education effect on knowledge, attitude, and practices of dengue prevention among school children: a systematic review

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## Abstract

**Introduction** Dengue is a mosquito-borne viral disease caused by dengue virus. The incidence of dengue has been steadily increasing globally in recent decades. The main treatment modality focuses on symptomatic relief. Primary prevention such as vector control and community education remain the mainstay of dengue control. School-based health education is one of the commonly applied interventions among school-age children to improve dengue control.

**Objective** This systematic review aimed to systematically analyse and determine the impact of various school-based health education programmes on the knowledge, attitudes, and practices of dengue prevention among school children.

**Methods** Articles related to school-based health education with dengue prevention were retrieved electronically from three different databases (EBSCOhost-Medline, Scopus, and Pubmed). Articles were screened by independent reviewers. Selected articles based on the inclusion and exclusion criteria were stored in Microsoft Excel. All included articles were critically appraised to assess the quality of the studies using the Mixed Method Appraisal Tool (MMAT).

**Results** Of the 582 articles identified, nine were included in the final review. Overall, there was an increase in knowledge, attitude, and practice regarding dengue following school-based health education. However, knowledge appeared to be the most significant variable as all studies showed a significant increase in knowledge. Hence, educational interventions exerted a more prominent impact on the knowledge of dengue infection compared to attitude and practices among school children.

**Conclusion** Further research is warranted to establish stronger evidence and evaluate the long-term impact of these interventions on students' knowledge, attitudes, and practice.

**Keywords** Dengue · School children · Health education · Prevention

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## 1 Introduction

Dengue is a mosquito-borne viral disease caused by dengue virus. In recent decades, dengue has evolved from a tropical disease to a global health concern, partly due to climate change and increased population mobilisation. The global incidence of dengue has significantly risen over the past two decades, presenting a major public health challenge. Between 2000 and 2019, the World Health Organization (WHO) reported a ten-fold increase in the number of cases, with the global total rising from 500,000 to 5.2 million [1, 2]. About 3.97 billion people live in dengue-prone areas across 138 countries worldwide [3]. More than one third of the cases are seen in Asia, including Malaysia, followed by Latin America and Africa [4]. In view of the widespread dengue endemicity in over 100 countries, close attention and concerted efforts are required for all relevant stakeholders to ensure effective dengue mitigation measures.

Currently, there is no specific therapy such as antiviral drugs for dengue infection. The management of dengue patients revolves around symptomatic treatment [5]. Vector control remains the mainstay of the prevention and control of dengue outbreaks [6]. However, there are significant challenges including a lack of community involvement and limited public knowledge regarding dengue transmission and prevention [7, 8]. Community involvement in dengue prevention and control relies on routine evaluation and improvement of knowledge, attitude, and practice among local communities. Therefore, it is vital to obtain a comprehensive understanding of the community baseline knowledge, attitudes, and practices of dengue to ensure the success and sustainability of vector control [9].

Health education programmes play an essential role in dengue prevention and management [10]. The community needs to get educated to enhance their awareness to improve behavioural changes. When delivered effectively to the right target audience, they can enhance knowledge, attitudes, and practices. Health education in dengue-endemic countries has been linked with an improvement in knowledge, attitude, and practice towards dengue prevention [11]. Schools are regarded as an ideal setting for health education and intervention programmes among children and young adults because schools serve as central hubs for children and will affect the whole school population, especially those in high-risk populations [12]. The World Health Organisation (WHO) recommended comprehensive school health services, based on the Global Standards for Health-Promoting Schools and Systems and the principles of the Western Pacific Region Health Promoting Schools framework [13, 14]. Based on these, various school-based health education modules for dengue prevention have been implemented throughout the world. However, there is a lack of mention regarding any previous systematic reviews on this topic, which warrants clarification.

This systematic review aimed to comprehensively analyse all existing research to determine the effectiveness of school-based dengue health education programmes in improving school children's knowledge, attitudes, and practices regarding dengue prevention and control. These findings will inform the development of future interventions to ensure effective mitigation of dengue burden, especially within school environments. The potential implications of this review for policy and practice include providing insights that could inform the development of national strategies for integrating dengue prevention into school curriculums. This early exposure can help foster a generation of informed individuals, contributing to long-term dengue control efforts. Additionally, the identification of effective implementation strategies could guide policymakers in crafting evidence-based policies to enhance the impact of dengue prevention education.

## 2 Materials and methods

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) updated guidelines [15]. The objective of this review was to identify the effects of school-based dengue health education programmes on knowledge, attitudes, and practices related to dengue prevention and control among school children. The components of PICO were established as follows:

- Population: School children
- Intervention: School-based dengue health education programmes
- Comparison: No intervention or alternative educational approaches (if available in studies)
- Outcome: Knowledge, attitudes, and practices related to dengue prevention and control

### 2.1 Search strategy

The literature search was conducted between April to June 2024, using EBSCOhost-Medline, NIH-Pubmed, and Scopus databases. The search strategy for this systematic review was developed using a comprehensive and methodical approach to ensure thoroughness and transparency. A qualified librarian and a Public Health Medicine Specialist with expertise in systematic reviews and database searching were consulted to refine the search terms, select relevant databases, and ensure adherence to best practices. Additionally, similar systematic reviews in the literature were reviewed to guide the development of the search approach, ensuring that no key studies were overlooked. The final search strategy was piloted in several databases and refined to maximize sensitivity and specificity. All retrieved articles were imported into Microsoft Excel and manual de-duplication was performed. The following keywords were used for the article search as in Table 1.

### 2.2 Eligibility criteria

Studies included in the review were those which were: (1) published in the English language; (2) original articles for intervention study including randomised controlled trials (RCTs), cluster RCTs, quasi-experimental studies (e.g., pre-post designs with comparison groups), controlled before-after studies, and mixed method (exploratory sequential) studies. In contrast, non-experimental studies, qualitative studies, and non-original articles such as conference proceedings, perspectives, commentary, opinions, reports, systematic reviews, and meta-analyses were excluded. Only studies published after 2020 were included. Restricting the review to studies published from 2020 onwards is justified as it ensures the synthesis focuses on contemporary school-based health education interventions that align with current practices and policies. Recent studies reflect advancements in teaching methods, tools, and strategies that are more applicable to modern educational systems. Older studies may rely on traditional approaches that lack relevance in today's context, potentially introducing outdated methodologies. Limiting the timeline also reduces heterogeneity in study designs, ensuring consistency and improving the applicability of findings to current and future efforts in dengue prevention education.

### 2.3 Study selection

Two independent reviewers screened the titles and abstracts of the retrieved materials against the inclusion and exclusion criteria. All potential articles identified during the initial screening were retained and the full texts were reviewed independently by the same reviewers in detail according to the eligibility criteria. The third reviewer was assigned to resolve any disagreements.

### 2.4 Critical appraisal and data extraction

Quality appraisal of each article was conducted using the Mixed Method Appraisal Tool (MMAT) 2018 [16]. MMAT focuses on methodological criteria, with five core quality criteria to be assessed for each article. One reviewer extracted the data before the data were assessed independently by the second reviewer. Eligible articles were analysed in detail using the content analysis method.

**Table 1** Keywords for literature search

| No | Component | Keywords |
|---|---|---|
| 1 | Topic | "Dengue" AND |
| 2 | Population | School* OR student* AND |
| 3 | Intervention | health education OR health promotion OR intervention OR campaign AND |
| 4 | Comparison | prevention OR control |
| 5 | Outcome | knowledge OR attitude* OR practice* |

*$p < 0.05$ indicates statistical significance

## 3 Results

The initial search yielded 411 articles from EBSCOhost-Medline, 151 from NIH-Pubmed, and 20 from Scopus as shown in the PRISMA flow diagram (Fig. 1). Subsequently, it was followed by a stringent selection screening process whereby each article was meticulously evaluated for its relevance to selection criteria. After the thorough assessment, only nine full-text articles were included in the final review. Table 2 shows a summary of the findings reported by the nine studies. All articles were published between 2020 and 2024. One article was RCT, two articles were cluster RCT, five articles were quasi-experimental studies, and another article used a mixed-method approach.

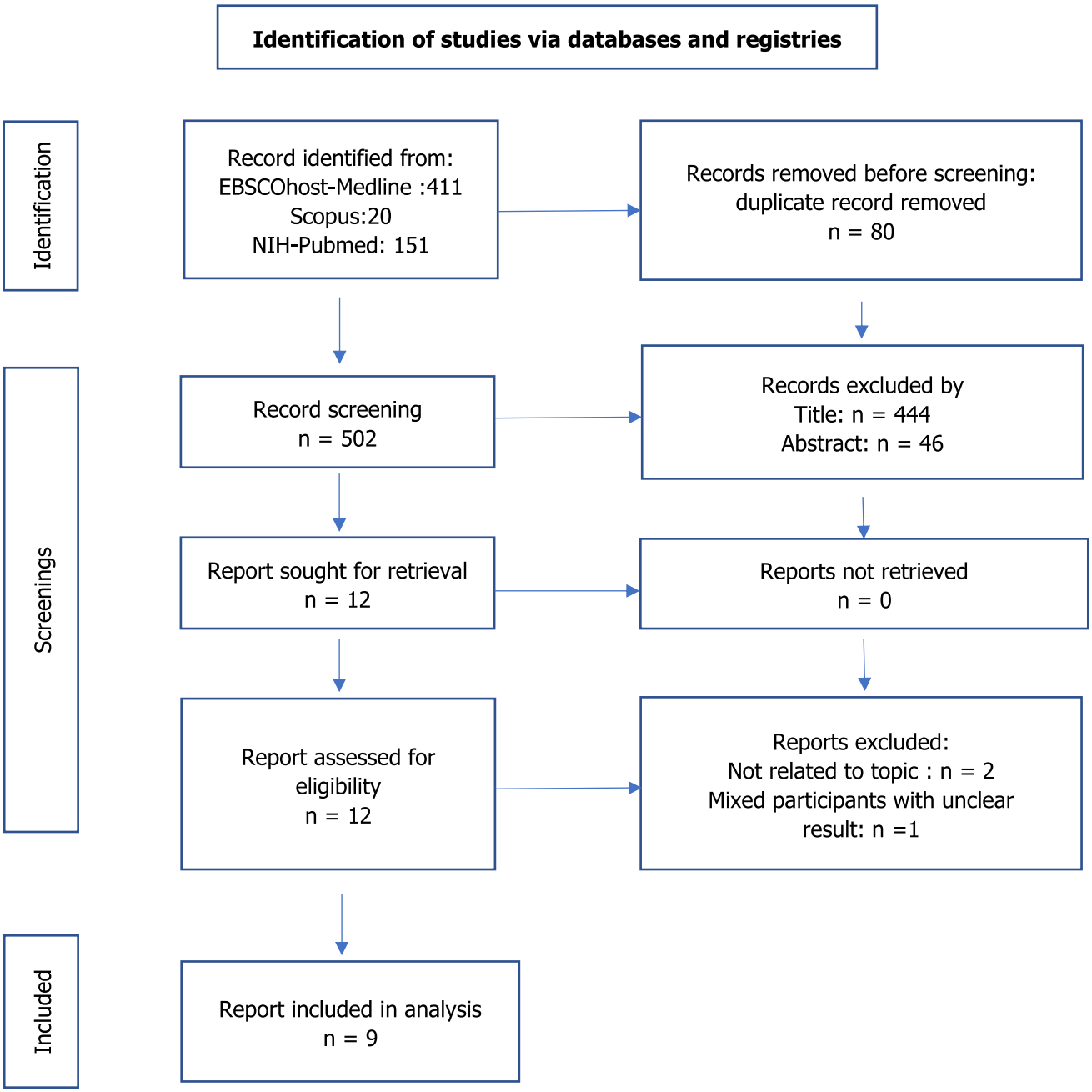


**Fig. 1** PRISMA flow diagram for the systematic review

**Table 2** Summary of accepted articles

| Author (Year) | Title | Study design | Participants | Intervention | Evaluation Strategy | Outcome |
|---|---|---|---|---|---|---|
| Roja et al. (2022) [17] | Effect of School-Based Educational Interventions on the Knowledge of Malaria and Dengue Among Higher Secondary School Children in Chennai, India: A Pre and Post-intervention Study | Quasi-experimental intervention | 284 students in the age group of 13–17 years | Three months of school-based educational interventions were delivered through PowerPoint-assisted lectures, participatory group activities, and a demonstration of mosquito larvae and their control | Self-administered questionnaire (before and after 3 months) | Improved knowledge ($p < 0.001$) |
| Aung et al. (2023) [18] | Effectiveness of dengue training programmes on prevention and control among high school students in the Yangon region, Myanmar | Randomised controlled trial | A total of 600 Grades 9 and 10 students: 300 in the intervention group and 300 in the control group | Visual aids, such as flipcharts, audiovisual media, and video, over 3 months period<br>Intensive training by entomologists before performing larval survey and using the survey form under the supervision | Questionnaire (pre and 3 months after) | KAP scores of the intervention group increased after the programme ($p < 0.001$) |
| Nawaz et al. (2020) [19] | Health Education Intervention is an Effective Tool for the Control of Dengue Disease in School Children | Quasi-experimental intervention | 80 students aged 8–13 years old | 6 weeks of educational programme | Questionnaire (Before and after 6 weeks) | Enhancement of dengue-related knowledge of school students ($p < 0.005$) |
| Krishnappa et al. (2023) [20] | Impact of School-Based Health Education on Dengue Prevention and Control in an Urban Area during an Epidemic | Quasi-experimental intervention | 625 high school students class 8th – 10th | Talk by the interns, PowerPoint presentation, video demonstration of larvae, and open house question and answer session<br>Household observational check | Semi-structured questionnaire (before and a week after intervention) | Knowledge and attitude of the students toward dengue significantly improved post-test<br>Significant change in behaviour practices as evident by reduction of breeding sites after intervention |
| Sarmiento-Senior et al. (2022) [21] | Improving knowledge, attitudes, and practices on dengue and diarrhoea in rural primary school students, their parents, and teachers in Colombia: A cluster-randomised controlled trial | Cluster randomised controlled trial | A total of 457 students aged 6 – 15 years old<br>103 heads of household<br>43 teachers aged between 25–61 years old | A total 2 years (Educational intervention, applied activities, and physical intervention | Questionnaire (pre- and 1–1.5 years after intervention) | Knowledge scores of students receiving dengue interventions increased by ( $p < 0.001$) but no significant changes in attitude and practice score |

**Table 2** (continued)

| Author (Year) | Title | Study design | Participants | Intervention | Evaluation Strategy | Outcome |
|---|---|---|---|---|---|---|
| Hermida et al. (2021) [22] | Learning-by-Teaching Approach Improves Dengue Knowledge in Children and Parents | Cluster randomised controlled trial | Study 1: 142 fourth graders aged 10 years old and 57 parents<br>Study 2: 97 parents of fourth-grade children | Standardised 30-min talk and 15-min grouping session | Questionnaire (Before the educational talk, immediately after the talk, after the grouping session, and a month after the intervention) | Overall, the knowledge regarding dengue is increased<br>Children that taught their parents what they learned, using a booklet, showed 2.53 more correct responses ($p < 0.05$) than children who listened to an unrelated topic |
| Santos et al. (2022) [23] | Prevention and control of mosquito-borne arboviral diseases: lessons learned from a school-based intervention in Brazil (Zikamob) | Quasi-experimental intervention | Of a total of 883 participants, 690 were students ranging in age from 14 to 41 years, with an average of $17 \pm 2$ years; and 193 were teachers from 22 to 64 years old, averaging $38 \pm 9$ years | Zikamob: e-health intervention consisted of a competition between schools to comply with preventive actions via content production for social networks, and the monitoring was performed for three months through a software | Questionnaire (before and after the intervention) | Students had appropriated the requisite knowledge, perceptions, and behaviours in such a way as to have greater overlap with the group of teachers |
| Kurniawan et al. (2020) [24] | The effectiveness of the One Health SMART approach on dengue vector control in Majalengka, Indonesia | Mixed-method design i.e. exploratory sequential | A total of 334 students were involved in this study including 171 students in the intervention group and 163 in the control group | OH-SMART—d pictures and stories about environmental hygiene, mosquitoes, DHF and dengue vector control, and how to monitor larva | Questionnaire (pre and immediately post t intervention) | Differences in knowledge, attitudes, and participation between the intervention and control groups ($p = 0.001$) |
| Ahbirami & Zuharah (2020) [25] | School-based health education for dengue control in Kelantan, Malaysia: Impact on knowledge, attitude and practice | Quasi-experimental intervention | 203 secondary school children between the age of 13–17 years in flooded and non-flooded area | 15-min lecture together with bilingual dengue awareness booklets that covered knowledge on DF and *Aedes* mosquitoes together with interactive sessions | Questionnaire (pre-intervention and one-week post-intervention) | Health education program significantly improved knowledge and practice in the flooded area and only improved knowledge in the unflooded area ($p < 0.05$) |


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### 3.1 Characteristics of the included studies

The articles included in this review were carried out in several low- and middle-income countries, including Argentina, Brazil, Colombia, India, Indonesia, Malaysia, Myanmar, and Pakistan. The study designs varied, including mixed methods, quasi-experimental, RCTs, and clustered RCTs. The composition of participants also varied across studies. In most studies, the target population was students while some studies also included teachers and parents. The sample size of the included studies ranged from 80 to 883 participants.

### 3.2 Educational intervention

The primary target population of the health educational programmes in the included studies were students as they were viewed as the key agents of change in disseminating knowledge who can influence behaviours related to dengue prevention within their families and communities. Various methods and materials were used as part of the health education interventions, including lectures, tutoring, group discussion, booklet, demonstration, and competition. Some of the studies also incorporated hands-on tasks as part of the intervention, i.e. home inspection to examine potential mosquito breeding sites and to demonstrate appropriate inspection techniques of breeding sites.

### 3.3 Outcomes

Mostly/Most commonly, the outcome of interest included knowledge, attitude, and practices. However, some studies assessed only knowledge but not attitude and practices. Several studies also analysed additional outcomes such as awareness, behavioural changes, and environmental changes. The main study instrument in these studies was questionnaires pre- and post-intervention. The outcomes of the interventions were measured in different periods, either immediately after the intervention, one week after the intervention, and/ or more than a month after the intervention.

### 3.4 Risk of bias

Quality appraisal of all nine studies was performed using MMAT version 2018 to determine the methodology quality of all studies [16]. This tool involved five criteria to assess the study quality. The details of this assessment for all the included studies are reported in Table 3.

The risk of bias assessment showed varying results across different study types. In the general screening, all articles passed, indicating that they met the basic inclusion criteria. For quantitative randomized controlled trials, half of the studies were considered to pass with low risk of bias, while the other half were deemed not applicable due to their design. In the quantitative non-randomized studies, most studies passed with a relatively low risk of bias, although about half

**Table 3** Quality appraisal of the studies

| | General Screening | | Quantitative randomised controlled trials | | | | | Quantitative non-randomised | | | | | Mixed methods | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Authors | S1 | S2 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 3.1 | 3.2 | 3.3 | 3.4 | 3.5 | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 |
| Roja et al. (2022) | Y | Y | n/a | n/a | n/a | n/a | n/a | Y | Y | Y | Y | Y | n/a | n/a | n/a | n/a | n/a |
| Aung et al. (2023) | Y | Y | Y | Y | Y | N | Y | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Nawaz et al. (2020) | Y | Y | n/a | n/a | n/a | n/a | n/a | Y | N | Y | Y | Y | n/a | n/a | n/a | n/a | n/a |
| Krishnappa et al. (2023) | Y | Y | n/a | n/a | n/a | n/a | n/a | Y | Y | Y | Y | Y | n/a | n/a | n/a | n/a | n/a |
| Sarmiento-Senior et al. (2022) | Y | Y | Y | Y | Y | N | Y | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Hermida et al. (2021) | Y | Y | Y | Y | Y | N | Y | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Santos et al. (2022) | Y | Y | n/a | n/a | n/a | n/a | n/a | Y | Y | Y | Y | Y | n/a | n/a | n/a | n/a | n/a |
| Kurniawan et al. (2020) | Y | Y | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | Y | Y | Y | Y | Y |
| Ahbirami & Zuharah (2020) | Y | Y | n/a | n/a | n/a | n/a | n/a | N | Y | Y | N | Y | n/a | n/a | n/a | n/a | n/a |

Y = Yes; N = No; n/a = Not applicable

were not applicable due to the study design nature. For mixed methods studies, only one study passed the assessment, with all others being deemed not applicable. These results provide an overview of the study quality, indicating that while most studies are of good quality, the variability in risk of bias highlights the need for careful interpretation of the findings.

## 4 Discussion

Overall, the school-based intervention programmes discussed in this review have been successful in raising awareness of dengue by increasing the knowledge and good practices against dengue infection among the participants. Thus, school-based health education programmes should be given an integral role as the tool to equip young people with the necessary strategies to protect themselves and their communities from dengue.

### 4.1 Schools as intervention sites

Schools are the suitable implementation sites for many health intervention programmes that aim to reach large numbers of children and adolescents [14]. The studies in this review showed that students were actively involved in direct interactive activities, related training, and 'search and destroy' activities in schools. One of the study conducted an intervention that included a home observational checklist among students for them to complete at home after receiving the training [20]. This approach can foster interaction with family members and neighbours, further promoting health awareness in the local communities through the multiplier effect. Another study demonstrated the multiplier impact of school-based interventions by showing how children shared the information with their parents, subsequently enhancing information retention among both students and parents [22]. In addition, another study also demonstrated how school-based programmes can serve broader community needs through focused education and physical measures [21].

Based on above findings, schools are ideal sites for implementing health intervention programs due to their ability to reach large numbers of children and adolescents. Future programs should leverage the multiplier effect demonstrated in the studies by encouraging students to engage not only in school-based activities but also in actions that involve their families and communities. For example, integrating home-based observational checklists, where students apply learned concepts at home, can enhance family involvement and further spread health awareness. Additionally, fostering peer-to-parent communication by encouraging students to share information with their parents can improve knowledge retention among both groups. Programs should also extend beyond the classroom by addressing broader community needs through collaborative efforts with local health authorities, ensuring a more sustainable impact. By combining these strategies, future health interventions can create a more comprehensive approach to health education, benefiting both individuals and the larger community.

### 4.2 Intervention programme design

The success of school-based programmes is closely dependent on designing the right content and tailoring the suitable delivery methods to the specific context and needs of its target population. Culturally relevant and age-appropriate educational materials, combined with interactive and participatory learning activities, are more likely to be appreciated by students and can instil long-term behavioural change [26]. This review reveals various learning methods that can be referenced by health practitioners to enhance students' knowledge, attitudes, and practices regarding dengue prevention. Traditional educational approaches such as lectures, exercises, and printed materials effectively improve knowledge and attitudes as shown across multiple studies [17, 19–21] Furthermore, practical elements and hands-on activities, such as demonstrations of mosquito breeding site elimination, the use of repellents, or household inspection can further enhance the effectiveness of the programme [22, 24, 25]. In addition, the use of digital health interventions such as mobile applications is also worth exploring as it represents innovative ways to educate the students [27]. More importantly, sufficient funding, material, and resources should be provided to ensure that school-based intervention programmes can be easily integrated and sustained in school policies and long-term planning [26].

### 4.3 Inter-agency collaboration

Collaboration between the health and education sectors is crucial to increase the impact of school-based interventions. Teachers can be equipped with the necessary resources and training to deliver effective dengue prevention messages.

Information about dengue, such as vectors and modes of disease transmission may be incorporated into the school curricula, especially in endemic areas [17, 19]. Additionally, involving teachers, parents, and community members in these programmes can reinforce the learning process outside the school and create a supportive environment for sustained behavioural changes among the students [21–23]. By adopting a holistic collaboration between different stakeholders including policy makers, school-based health education programmes can reduce the dengue burden and empower future generations against the epidemic [24].

### 4.4 Theory-based interventions

A review of the interventions across the nine studies reveals a notable gap. None of the educational programmes explicitly incorporated a theoretical behavioral model as part of their study design. The integration of behavioural change theories into health education intervention programmes can significantly enhance their effectiveness [28]. Theories like the Information Motivation Behavioral, Health Belief Model, Social Cognitive Theory, and the Transtheoretical Model offer potential frameworks for understanding factors that influence health behaviours and strategies for promoting change. By designing school-based health education based on behavioural change theories, the intervention is likely to exert a more positive impact in encouraging sustainable preventive practices among children, beyond just increasing knowledge [29].

By applying theory-based education, the potential to enhance the effectiveness of health interventions would be evident through a more structured and strategic approach to influencing behaviour. The integration of behavioural change theories, such as the Information Motivation Behavioural Model, Health Belief Model, Social Cognitive Theory, and the Transtheoretical Model, provides a framework for understanding the underlying factors that drive health behaviours. This approach extends beyond merely increasing knowledge, focusing on changing attitudes, beliefs, and practices. With school-based health education grounded in these theories, interventions are more likely to achieve sustained behaviour change, leading to the consistent adoption of preventive measures among children, thereby ensuring long-term success in dengue control.

### 4.5 Recommendations

To ensure a well-developed intervention programme, a theoretical framework can be used to provide a structured methodology for understanding and influencing behavioural changes. The intervention content must be tailored to the cultural and social context of the target audience. In the current era, the integration of digital technologies in education methods is crucial to engage students more effectively beyond the traditional practice. A variety of techniques, including lectures and interactive exercises, can be incorporated to accommodate different learning styles and strengthen the effectiveness of education programmes in real-life situations. Continuous evaluation is also essential to ensure their effectiveness and sustainability. Furthermore, encouraging local ownership and establishing collaborations between public health authorities, community organisations, and the private sector would also improve and enhance the sustainability and impact of the programmes. However, the generalisability of these findings to different contexts or populations should be carefully considered, as cultural, social, and environmental differences may affect the effectiveness of the intervention in diverse settings.

Future research should focus on specific aspects of engagement, interaction, and stakeholder involvement in health interventions. Key areas for exploration include how student engagement and interactive methods such as peer learning and family involvement impact the retention and application of health knowledge, particularly in dengue prevention. Additionally, investigating the role of stakeholders such as educators, parents, and public health authorities in supporting or hindering program implementation will provide insights into optimizing collaboration and ensuring the sustainability of interventions across diverse contexts.

### 4.6 Limitations and strength

As with any research, this systematic review is not without limitations. The role of publication bias in this systematic review must be acknowledged as grey literature was not included. Furthermore, language bias should also be considered as only English articles were included even though many of the studies included were sourced from several countries where English is not the primary language (Indonesia, China, and Japan). Despite these limitations, this systematic review synthesised crucial research evidence regarding the effects of school-based health education programmes for dengue prevention and control, which may serve as a guide to enhance the delivery strategies of these programme.

## 5 Conclusions

This review highlighted the effectiveness of school health education programs in improving students' knowledge, attitudes, and practices related to dengue control. While the existing evidence shows a significant improvement in students' knowledge of dengue prevention, further intervention studies are needed to establish more robust evidence on the impact of these programs on students' attitudes and behaviours. Additionally, more research is needed to assess the long-term effects of school-based interventions and their broader impact on community health. Understanding these aspects will provide valuable insights for policymakers, enabling them to refine current policies or develop new strategies for enhancing the effectiveness of school-based health education programs in dengue control.

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**Data availability** Data is provided within the manuscript.

## Declarations

**Ethics approval and consent to participate** This systematic review is part of need analysis under study "Effectiveness of Combination Integrated Dengue Education and Learning Module (iDEAL) and Aedestech Mosquito Home System (AMHS) in Improving Knowledge, Attitude, Practice, Environmental Cleanliness Index, and Aedes Index among Schoolchildren in Selangor and Kuala Lumpur which ethical approval was obtained from the Ethics Committee for Research Involving Human Subjects of Universiti Putra Malaysia (JKEUPM-2023–635) and the National Medical Research Registration of Malaysia (NMRR) (NMRR ID-23–02822-CPZ) [30, 31].

**Competing interests** The authors declare no competing interests.



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