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Original Article

Training community health volunteers on mosquito-repellent plants to support urban dengue prevention: A sequential explanatory mixed-methods study in Jakarta

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Abstract

Dengue remains a major urban public health challenge in Jakarta, Indonesia, where community-level vector control often relies on reactive chemical-based approaches. Mosquito-repellent plants may serve as a practical educational medium to support environmentally oriented dengue prevention, but evidence on their use in community health volunteer training remains limited. This study evaluated mosquito-repellent plant training among community health volunteers in Jakarta using a sequential explanatory mixed-methods design. Knowledge was assessed before and after training, while qualitative interviews explored implementation readiness, barriers, support systems, and sustainability. Quantitative data were analyzed using the Wilcoxon signed-rank test, and qualitative data were analyzed thematically and integrated with the quantitative findings. Knowledge shifted toward higher categories after training, with the proportion of participants in the good knowledge category increasing from 26.7% to 56.7%. The median knowledge score increased from 60 to 80, and the improvement was statistically significant ($Z=-2.103$; $p=0.036$), with a moderate effect size ($r=0.38$). Qualitative findings indicated that volunteers perceived the training as practical and relevant to dengue prevention. However, implementation readiness was influenced by seedling availability, household participation, mentoring, and support from neighborhood leaders, village authorities, and primary health care centers. These findings suggest that mosquito-repellent plant training can improve volunteers' knowledge and initial readiness to support community-based mosquito breeding site eradication and environmentally oriented dengue prevention, although sustained implementation requires continued mentoring, resource provision, and local institutional support.

Keywords: Dengue prevention, mosquito-repellent plants, community health volunteers, knowledge improvement, mixed-methods evaluation

Introduction

Dengue remains one of the major public health challenges, and its burden has increased alarmingly, with transmission expanding to various regions and case numbers rising in endemic countries [1]. In Indonesia, dengue continues to pose a serious public health problem due to its widespread distribution and recurrent outbreaks across various regions, including urban settings such as Jakarta, the country's capital [2]. Urban characteristics, such as high population density, increased mobility, changes in residential environments, and the presence of household water storage containers, may increase the risk of *Aedes aegypti* breeding, the primary vector of dengue

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transmission [3,4]. Therefore, dengue prevention in urban areas requires an approach that goes beyond curative responses or temporary control measures and instead strengthens household- and community-based preventive practices.

At the community level, dengue vector control still frequently relies on chemical-based approaches, particularly space spraying or fogging. Although fogging may be useful in specific outbreak situations, it is largely reactive, provides only short-term vector reduction, and does not address the environmental conditions that sustain mosquito breeding [5]. Repeated insecticide use may also contribute to vector resistance and impose ecological pressure on residential environments [5,6]. Therefore, integrated vector control strategies that combine environmental management, community education, larval surveillance, and community-based interventions are increasingly recognized as essential for sustainable dengue prevention [3,4].

In the Indonesian context, community health volunteers and larval monitoring cadres play an important role in mosquito breeding site eradication activities, known as *Pemberantasan Sarang Nyamuk* (PSN), including the 3M Plus strategy. This strategy consists of draining, covering, and recycling water storage containers, along with additional measures to prevent mosquito bites and reduce mosquito breeding. Several studies have found that structured health education can improve dengue-related knowledge, attitudes, and preventive practices, particularly knowledge, while also strengthening community understanding and engagement in dengue prevention activities [7-9]. Community-based interventions and health education have therefore been widely recognized as important strategies for improving public knowledge, participation, and readiness for dengue prevention [10]. However, their success depends not only on the delivery of information, but also on sustained mentoring, adequate resources, support from local leaders, and household acceptance of recommended preventive practices [11-13].

One supportive approach for preventing mosquito bites is the use of mosquito-repellent plants. Several plants, including *Cymbopogon citratus, Lavandula angustifolia*, and *Rosmarinus officinalis*, contain volatile compounds with potential mosquito-repellent activity [14-16]. Essential oils and other plant-derived compounds have also been explored as alternatives or complements to synthetic repellents. However, their use should be positioned as a supportive strategy rather than a primary substitute for integrated vector control [16,17]. In public health practice, training on mosquito-repellent plants may serve as a practical educational medium for community health volunteers because it is visual, easy to understand, closely related to household practices, and able to reinforce environmentally oriented PSN/3M Plus messages.

Although dengue prevention education, community-based vector control, and plant-based repellents have been widely discussed, evidence remains limited on how mosquito-repellent plant training affects community health volunteers' knowledge and which contextual factors influence implementation readiness at the community level. Most previous evidence has focused on community knowledge outcomes, larval indices, or the effectiveness of specific vector control interventions. Limited attention has been given to studies that integrate quantitative assessment of knowledge change with qualitative exploration of implementation barriers and facilitating factors [12,18,19]. This gap is important because improved knowledge does not automatically translate into sustained preventive practice without support from local institutions, adequate resources, mentoring, and facilitation.

Based on this gap, the present study aimed to evaluate mosquito-repellent plant training among community health volunteers in Jakarta using a sequential explanatory mixed-methods design. The quantitative component assessed changes in volunteers' knowledge before and after training, while the qualitative component explored their experiences, motivation, barriers, social support, and perceptions of sustainability. This study is expected to provide an integrated understanding of knowledge improvement and implementation readiness, rather than to assess direct effects on larval indices or dengue incidence.

Methods

Study design and setting

This study employed a sequential explanatory mixed-methods evaluation design to assess changes in community health volunteers' knowledge following mosquito-repellent plant training

and to explore contextual factors influencing implementation readiness. This design was selected because training evaluation requires not only quantitative measurement before and after the intervention, but also qualitative explanations of participants' experiences, barriers, support systems, and perceptions of sustainability [18]. The quantitative component used a one-group pre-test and post-test design, followed by a qualitative component to explain the quantitative findings. The study was conducted in Kemayoran District, Central Jakarta, Indonesia, in May 2024. Since this study evaluated a real-world community training program delivered to available volunteers, no control group was included. Therefore, the findings should be interpreted as changes associated with the intervention rather than as definitive causal effects. This study was not designed to measure entomological indices, vector density, or dengue incidence.

Participants and eligibility criteria

The participants were active community health volunteers in Kemayoran District, Central Jakarta, who were involved in community health education and dengue prevention activities. Participants were eligible if they were active volunteers, agreed to participate in the training, and completed both the pre-test and post-test assessments. Participants were excluded if they did not attend the full training session or did not complete one of the evaluation instruments. For the qualitative component, participants were selected from those who had completed the training and were considered able to provide diverse perspectives on implementation.

Sample size and sampling

The sample size was determined by the number of active community health volunteers available and willing to participate in the training program. A total of 30 volunteers were included in the quantitative component. Participants were recruited using purposive sampling based on their active role in community health education and dengue prevention. For the qualitative component, six participants were selected using maximum variation purposive sampling based on age, educational background, and length of service as community health volunteers.

Intervention

The intervention consisted of a single structured mosquito-repellent plant training session lasting approximately 3 hours. The training covered dengue transmission, source reduction, 3M Plus practices, the role of mosquito-repellent plants as a supportive strategy for preventing mosquito bites, and simple techniques for planting and maintaining these plants in household environments. The session was facilitated by the research team, whose expertise included public health, environmental health, and community-based disease control. Training media included PowerPoint presentations, live plant specimens, educational brochures, discussion, and question-and-answer sessions.

Data collection

Quantitative data were collected using a knowledge questionnaire administered before and after the training. The questionnaire consisted of 10 multiple-choice items developed from the training objectives and covered dengue, transmission vectors, source reduction, 3M Plus principles, mosquito-repellent plants, and the role of community health volunteers in public education. Content validity was assessed by two public health specialists and one environmental health expert to ensure that the items represented the training content. Since the questionnaire was designed specifically for this training program rather than as a standardized psychometric instrument, formal reliability testing was not performed.

Post-training evaluation data were also collected to assess participants' willingness to continue the program and their perceptions of program sustainability. Qualitative data were collected through in-depth interviews and field notes after the training.

Study outcomes

The primary outcome was the change in community health volunteers' knowledge scores before and after mosquito-repellent plant training. Each correct answer was scored as 1 and each incorrect answer as 0, giving a total raw score ranging from 0 to 10. The raw score was then

converted to a 0–100 scale. Knowledge scores were categorized as low (≤40), moderate (41–60), good (61–80), and very good (81–100).

Secondary outcomes included changes in knowledge categories, participants' willingness to continue the program, and perceptions of program sustainability. Qualitative outcomes included participants' experiences, motivation, implementation barriers, social and institutional support, and perceived sustainability of mosquito-repellent plant use in community-based dengue prevention.

Qualitative study

The qualitative component was conducted to explain the quantitative findings and explore factors influencing implementation readiness. Six community health volunteers were purposively selected using the maximum variation principle based on age, educational background, and length of service. The interviews explored participants' experiences during the training, motivation to implement mosquito-repellent plant activities, perceived barriers, social and institutional support, and perceptions of sustainability. Qualitative data were analyzed thematically through repeated reading, coding, category development, and identification of major themes.

Statistical analysis

Quantitative data were analyzed descriptively and inferentially. Participant characteristics, knowledge categories, willingness to continue the program, and perceptions of sustainability were summarized as frequencies and percentages. Knowledge scores were summarized using medians and interquartile ranges (IQRs). Pre- and post-training scores were compared using the Wilcoxon signed-rank test, a non-parametric test suitable for paired, discrete knowledge scores. The Wilcoxon effect size was calculated as $r=|Z|/\sqrt{N}$ to estimate the practical magnitude of knowledge improvement. A two-tailed p-value <0.05 was considered statistically significant. Mixed-methods integration was conducted using a joint display linking quantitative findings, qualitative themes, and integrated interpretations.

Results

Participant characteristics

A total of 30 community health volunteers participated in the training and their characteristics are presented in **Table 1**. Most participants were older adults (19; 63.3%) and had completed senior high school education (24; 80.0%). More than half had served as community health volunteers for more than five years (56.7%), while six participants (20.0%) had served for less than two years and seven participants (23.3%) had served for 3–5 years (**Table 1**).

Table 1. Characteristics of community health volunteers participating in the mosquito-repellent plant training (n=30)

Variable	Frequency	Percentage
Age		
Adult	11	36.7
Older adult	19	63.3
Education		
Elementary school–junior high school	6	20.0
Senior high school	24	80.0
Length of service		
<2 years	6	20.0
3–5 years	7	23.3
>5 years	17	56.7

Changes in knowledge after mosquito-repellent plant training

Knowledge shifted toward higher categories after the training (**Table 2**; **Figure 1**). The number of participants with low and moderate knowledge decreased from 5 to 2 and from 17 to 11, respectively, whereas those with good knowledge increased from 8 to 17. No participant reached

the very good category in either assessment. The median knowledge score increased from 60 (IQR: 60–80) before training to 80 (IQR: 60–80) after training (**Table 2**).

Paired knowledge scores were compared using the Wilcoxon signed-rank test. Post-training scores were significantly higher than pre-training scores (Z=−2.103; p=0.036), with a moderate effect size (r=0.38).

Table 2. Distribution of pre-test and post-test knowledge scores (n=30)

Knowledge category	Pre-test	Post-test
	n (%)	n (%)
Low (≤40)	5 (16.7)	2 (6.7)
Moderate (41–60)	17 (56.7)	11 (36.7)
Good (61–80)	8 (26.7)	17 (56.7)
Very good (81–100)	0 (0.0)	0 (0.0)
Median (interquartile range)	60 (60–80)	80 (60–80)

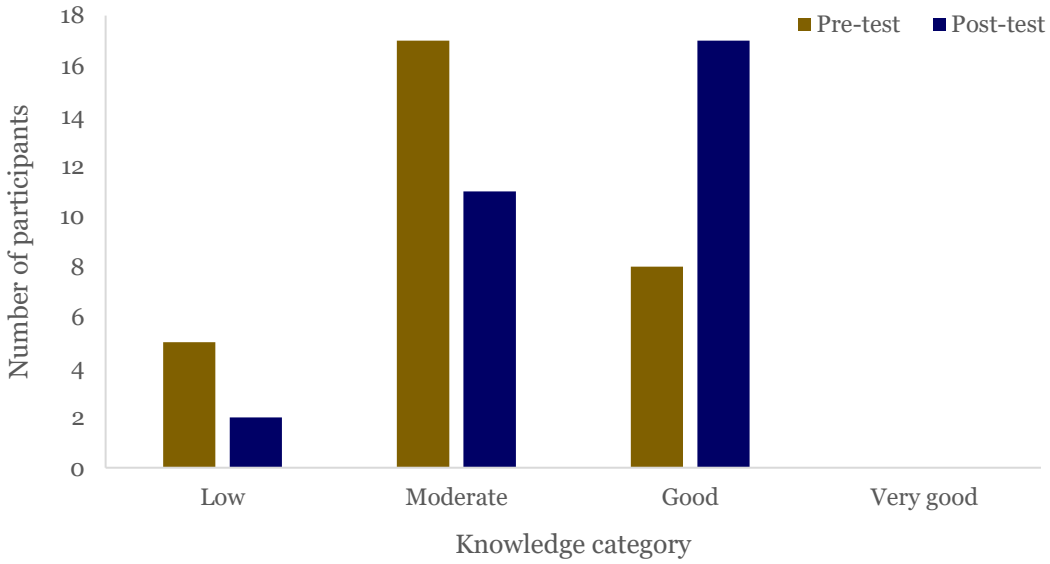

Figure 1. Distribution of knowledge levels before and after mosquito-repellent plant training.

Qualitative results: Interview themes on implementation readiness and sustainability

The thematic analysis identified four main themes related to implementation readiness and sustainability: internal motivation, implementation barriers, social and policy support, and perceptions of sustainability (**Table 3**). Volunteers reported that the training was relevant to their role in community dengue prevention and increased their motivation to promote safer and more environmentally oriented household practices. However, implementation was influenced by practical barriers, particularly limited seedling availability and variable household participation.

Table 3. Interview themes on implementation readiness and sustainability of mosquito-repellent plant training

Theme	Representative quotation	Evaluative meaning
Internal motivation	"I joined because I wanted to help the community without using chemicals…"	The training was well received because it was relevant to the volunteers' role in dengue prevention education.
Implementation barriers	"Residents are willing to plant them if seedlings are provided; they are reluctant to buy them themselves…"	Knowledge alone is insufficient without seedling availability and community support.
Social and policy support	"Without follow-up from the subdistrict, this program may stop halfway…"	Sustainability requires support from neighborhood leaders, village authorities, and primary health care centers.

Theme	Representative quotation	Evaluative meaning
Perceptions of sustainability	"This program is good, but it needs mentoring; training alone is not enough..."	Training should be followed by mentoring and monitoring.

Participants also emphasized that sustained implementation would require support from neighborhood leaders, village authorities, and primary health care centers. Training alone was considered insufficient without follow-up mentoring, monitoring, and resource support. Overall, the qualitative findings indicate that mosquito-repellent plant training was well accepted by volunteers, but its translation into routine community practice depends on adequate facilitation and local institutional support.

Mixed-methods integration

The integration of quantitative and qualitative findings showed that mosquito-repellent plant training improved volunteers' knowledge, but sustained implementation depended on broader contextual support (**Table 4**). Quantitatively, knowledge scores increased significantly after training, with a moderate effect size. Qualitatively, volunteers perceived the training as practical and relevant to their role in dengue prevention; however, they emphasized that implementation would require seedling availability, household participation, mentoring, and support from neighborhood leaders, village authorities, and primary health care centers.

The joint display further indicated that although 80.0% of participants were willing to continue the program, 56.7% remained uncertain about its sustainability without adequate resources and institutional facilitation. These findings suggest that the training functioned as an initial cognitive strengthening strategy, while translation into routine PSN/3M Plus practice requires continued mentoring, resource provision, and integration into existing community-based dengue prevention activities.

Table 4. Joint display integrating quantitative and qualitative findings in the evaluation of mosquito-repellent plant cultivation training for community health volunteers using a sequential explanatory approach

Quantitative finding	Qualitative finding	Integrated interpretation
Significant improvement in knowledge (p=0.036)	"The material was clear and easy to follow..."	The training was practical at the cognitive level.
Post-test scores decreased in 13.3% of participants	"I found it difficult to remember because I am already old..."	Visual methods and additional guidance are needed for certain groups.
56.7% felt uncertain about program sustainability	"Without seedlings and support from neighborhood leaders, this program will stop..."	Knowledge is not automatically translated into practice without systemic support.
80% were willing to continue the program	"As long as seedlings are provided and residents participate..."	Sustainability can be achieved when supported by resources and institutional facilitation.

Discussion

The findings of this study indicate that community-based training in mosquito-repellent plants significantly improved the knowledge of community health volunteers in Kemayoran, Jakarta. The increase in median knowledge scores and the shift from predominantly moderate to predominantly good knowledge categories from moderate to good suggest that short, practical training closely aligned with household contexts can strengthen volunteers' cognitive readiness to support dengue prevention. This finding is consistent with recent studies showing that health education and community-based interventions play an important role in improving knowledge, attitudes, and practices related to dengue prevention, particularly when delivered in a context-specific manner and relevant to local communities' roles [20-22]. Reviews of educational interventions for *Aedes*-borne diseases further emphasize that community-engaged education strategies should aim not only to improve knowledge but also to strengthen community capacity to recognize risks and to repeatedly perform preventive actions [23-25].

These findings are important because dengue prevention in urban areas cannot rely solely on curative responses or reactive vector control measures. The household environment is a

critical setting for *Aedes* breeding because of the presence of water containers, residential density, population mobility, and variation in environmental hygiene practices. Systematic reviews of household-level *Aedes* interventions have shown that domestic environmental management, household protection, and source reduction can reduce entomological indicators. However, their effects are strongly influenced by intervention coverage, intensity, and sustainability [3,4]. Recent meta-reviews on dengue vector control also emphasize that no single method is sufficient for all contexts; therefore, locally adapted approaches that combine education, environmental management, personal protection, and continuous monitoring remain necessary [26].

Mosquito-repellent plant training should be positioned as an educational and supportive component rather than as a standalone intervention for reducing vector populations. Although plant-based compounds and essential oils have shown repellent activity against *Aedes aegypti*, their effectiveness depends on formulation, concentration, duration of protection, and field-use conditions [14,17]. Therefore, the main value of this training lies not in demonstrating the biological effectiveness of mosquito-repellent plants, but in using them as a practical, visual, and household-relevant educational medium to reinforce PSN/3M Plus messages within an integrated vector management framework [8].

The qualitative findings show that increased knowledge does not automatically guarantee sustained implementation. The motivation of volunteers to assist residents through safer and more environmentally friendly approaches is an important enabling factor. However, barriers such as limited seedling availability, low household participation, insufficient follow-up, and weak institutional support may constrain program implementation. This finding is consistent with systematic reviews on community participation in dengue control, which indicate that the success of community-based interventions is determined by a combination of individual, community, social, and institutional support factors [10]. Recent community policy studies also emphasize that effective dengue control requires locally contextualized strategies, strengthened roles of health volunteers, improved risk communication, and cross-sectoral collaboration [27,28].

The integration of quantitative and qualitative findings strengthens the understanding that knowledge is an important proximal outcome but is not sufficient to produce sustained practice change. Quantitatively, the results showed a significant increase in knowledge scores with a moderate effect size; however, individual score variations—including participants who showed no change or a decline—indicate the need for more adaptive learning strategies. Qualitatively, volunteers emphasized the need for mentoring, resource provision, and support from RT/RW, urban village authorities, and primary health care centers to translate knowledge into household-level action. This pattern aligns with dengue KAP studies showing that knowledge alone does not always correspond directly to preventive practices, as practices are influenced by risk perception, trust in the health system, social norms, and access to resources [20,21]. Therefore, the mixed-methods findings of this study demonstrate that training serves as an initial step in strengthening volunteers' capacity, while sustainability requires a broader support system.

These findings are also consistent with recent evidence that structured and participatory health education can improve knowledge, attitudes, and practices related to dengue prevention. Systematic reviews have shown that school-based education has most consistently been associated with knowledge improvement [7,8]. Participatory studies in Thailand have also shown that dengue education models can enhance community understanding and engagement. At the same time, primary school-based approaches linked to larval index surveillance strengthen participants' understanding of the relationship between environmental conditions and dengue risk [9]. Thus, volunteer training in this study should be understood as a practical learning process that should be repeated, participatory, and connected to routine prevention activities.

The findings also highlight the need to strengthen training design to better incorporate participants' characteristics. Because most participants were older adults, it is possible that differences in learning pace or information retention contributed to the observed variation in knowledge scores. However, this interpretation remains speculative because subgroup analyses by age were beyond the scope of the present study. Therefore, future training should not rely solely on lectures but should be complemented by direct demonstrations, simple visual media, hands-on planting activities, concise guidance sheets, and repetition of key messages. Recent

reviews of *Aedes*-related educational interventions emphasize that educational programs are more likely to be effective when they employ multimodal, participatory approaches tailored to the characteristics of the target population [24,25]. In addition, studies on dengue KAP among health volunteers in urban Indonesia show that differences in knowledge, attitudes, and preventive practices may be influenced by education, experience, and program support; therefore, follow-up training should consider variations in participants' learning needs [21].

These findings support the incorporation of mosquito-repellent plant training into routine volunteer activities and PSN/3M Plus programs, rather than treating it as a one-time activity. The relevance of this approach is not limited to Jakarta but also applies to other Indonesian urban areas that implement community-based PSN/3M Plus activities. In Mataram City, mass PSN activities and dengue prevention education have also been reported as part of efforts to strengthen community awareness of dengue, including through 3M/4M Plus campaigns and community involvement in the eradication of mosquito breeding sites [29,30]. This suggests that mosquito-repellent plant training may serve as a supportive educational medium for strengthening household-level dengue prevention messages, in line with 3M Plus recommendations that also include the use of mosquito repellents and the planting of mosquito-repellent plants [31].

Such integration can be implemented through monthly volunteer agendas, household visits, larval monitoring, family education, and demonstrations on plant maintenance within RT/RW neighborhoods. This approach is consistent with recent evidence that dengue control is strengthened when interventions are implemented as coherent packages that include education, environmental monitoring, source reduction, household protection, and local institutional support [26,28]. Within a broader framework, the One Health approach to integrated vector management emphasizes the importance of monitoring, evaluation, cross-sectoral coordination, and actionable indicators to ensure that programs do not remain limited to educational activities but develop into sustainable prevention systems [32,33].

The findings of this study should be interpreted cautiously because the study did not measure larval indices, mosquito density, long-term household behavior change, environmental quality, or dengue incidence. Therefore, the findings cannot be used to conclude the effectiveness of mosquito-repellent plants in reducing vector populations or dengue cases. The most appropriate interpretation is that the training was associated with improved knowledge and strengthened volunteers' initial readiness for implementation.

This study involved only 30 community health volunteers from a single urban community, which limits statistical power and external generalizability. Nevertheless, this sample represents the entire group of active volunteers participating in the community training program and is appropriate for an exploratory mixed-methods evaluation intended to assess feasibility and implementation readiness rather than population-level effectiveness.

Conclusion

In this one-group pre-post evaluation, community-based training in mosquito-repellent plants was associated with significantly higher knowledge scores among community health volunteers in Kemayoran, Jakarta. The qualitative findings indicate that implementation readiness was shaped by volunteers' motivation, seedling availability, household participation, post-training mentoring, and local institutional support. The training may therefore serve as a supportive educational component of PSN/3M Plus and environmentally oriented dengue prevention at the community level. Because this study did not measure entomological indicators, household behavior change, or dengue incidence, the findings should be interpreted as evidence of improved knowledge and initial implementation readiness rather than direct evidence of vector-control effectiveness. Future studies should use longitudinal or controlled designs and measure larval indices, household practices, and periodic follow-up. Integrating mosquito-repellent plant education into routine community-based dengue prevention activities, alongside ongoing mentoring and institutional support, may help translate knowledge gains into sustained practice.

Ethics approval

Ethical approval for this study was obtained from the Research Ethics Committee of Universitas YARSI (No. 106/KEP-UY/EA.10/V/2024, dated May 20, 2024). All participants were informed of the study procedures and provided consent prior to data collection.

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

During manuscript preparation, an AI-based language model, ChatGPT, was used to support language refinement, improve readability, and provide technical writing assistance. The AI tool was not used for data collection, statistical analysis, data interpretation, or drawing scientific conclusions. All AI-assisted outputs were critically reviewed and verified by the authors, and the final decisions and interpretations presented in this article were solely made by the authors.

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