Review Article

Community-based intervention in mosquito control strategy: A systematic review

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Abstract

As part of the World Health Organization's One Health Initiative, vector-borne disease control requires multidisciplinary and community involvement. This review examined community-based mosquito control intervention methods, their efficacy, and limitations. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline, data were extracted from four medical databases: PubMed, Clinical Key, ProQuest, and ScienceDirect, covering the period from 2014 to 2023. The search used the keywords "community intervention," "vector control," and "mosquito." Filters were applied for full text, primary sources, scholarly journals, and publications within the last ten years (2014–2023). Studies without community intervention components were excluded. The initial search retrieved 1,035 articles, and 32 full-text articles were selected and assessed for eligibility, with 15 papers included in the final analysis. The included studies focused on arbovirus or malaria vectors and used randomized controlled trials (RCTs), pre- and post-intervention surveys, community-based implementation surveys, or qualitative research designs. Commonly applied interventions included community-driven vector population control and community education. Overall, the studies reported improvements in outcome measures such as entomological indices, community knowledge and practices, costs, and disease incidence or prevalence. However, some studies reported challenges with community perception and acceptance. In conclusion, this review consistently demonstrated a positive impact of community interventions on managing mosquito control.

Keywords: Vector-borne disease, one health, integrated vector management, vector control, community education

Introduction

Mosquitoes continue to become a health concern due to their swift adaptation to new environments, extensive breeding capabilities, insecticide resistance, and ability to modify their feeding habits to evade control efforts [1]. Most of the mosquito's life stages occur in water, with the adult stage being the only terrestrial phase [2]. Hence, effective vector control requires a comprehensive and interdisciplinary approach that includes eliminating breeding sites, managing mosquitoes during both their larval and adult phases, and implementing barrier methods [3].

Considering the potential transmission of mosquito-borne diseases through bites from infected individuals, mosquito-borne disease management strategies must prioritize treating the disease in humans and eliminating the vector [4]. This strategy requires the collaboration of multiple disciplines and the engagement of the community as part of the World Health

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Organization (WHO)'s One Health initiative [5]. A rational decision-making process is necessary for the optimal use of resources for vector control, defined as integrated vector management (IVM) [6]. The success of IVM implementation at the local level heavily relies on community participation [7]. The aim of this review was to determine modes of community-based intervention in mosquito control strategy and their effectiveness. Furthermore, the findings can offer insight into formulating a mosquito control strategy involving the community.

Methods

Study design and protocol registration

This systematic review was carried out using a predefined protocol based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for reporting systematic reviews [8]. The study protocol also aligns with the International Prospective Register of Systematic Reviews (PROSPERO), though it was not registered because the study's output was not directly related to health outcomes.

Literature search strategy and eligibility criteria

The literature search involved databases, including PubMed, Clinical Key, ProQuest, and ScienceDirect, using the keywords of "community intervention," "vector control," and "mosquito." Filters were set for full-text articles, source type, and publication dates within the last ten years (2014–2023). Original articles (academic or research papers) written in English and published in the previous ten years were included. Study design on randomized control trials, pre- and post-intervention surveys, and qualitative research were also included. Studies lacking community intervention were excluded. Additionally, review studies were omitted. The inclusion and exclusion criteria, as well as the search strategy, were verified and implemented. The electronic search was then used to establish the first database. After eliminating duplicate articles, all citations were screened based on title and abstract. Subsequently, the complete manuscripts of qualified records were acquired separately for additional screening. The final papers were selected after resolving disagreements through collaborative discussions and carefully considering the established inclusion and exclusion criteria.

Data collection and synthesis

The data highlighted from the included articles were basic and specific information. The basic information included authors, article title, year of publication, country where the study was conducted, study period, and publisher. Specific information included type of research, study participants, modes of intervention, focus of mosquito-borne disease, outcome measures, and study results. Modes of intervention included community seminars, multimedia lectures, and other education protocols. Study outcomes ranged from the implementation rate of certain behaviors against mosquito transmission, morbidity, and mortality related to mosquito-borne diseases, knowledge, attitude, and practice (KAP) regarding mosquito-related issues. The homogeneity data of the qualitative study was not feasible. Therefore, no further meta-analysis was conducted.

Results

Study selection

A total of 1,035 articles were identified through database searches. After removing duplicates, 783 articles were screened based on their titles and abstracts. The main reasons for exclusion were irrelevant topics, not research papers, or lack of full-text articles (**Figure 1**). Subsequently, 32 full papers were further evaluated to determine their eligibility. Upon further evaluation, another 17 papers were excluded, mostly due to irrelevant outcomes such as the absence of community intervention. At the end of the inclusion process, 15 primary articles were included in the qualitative analysis [9-23].

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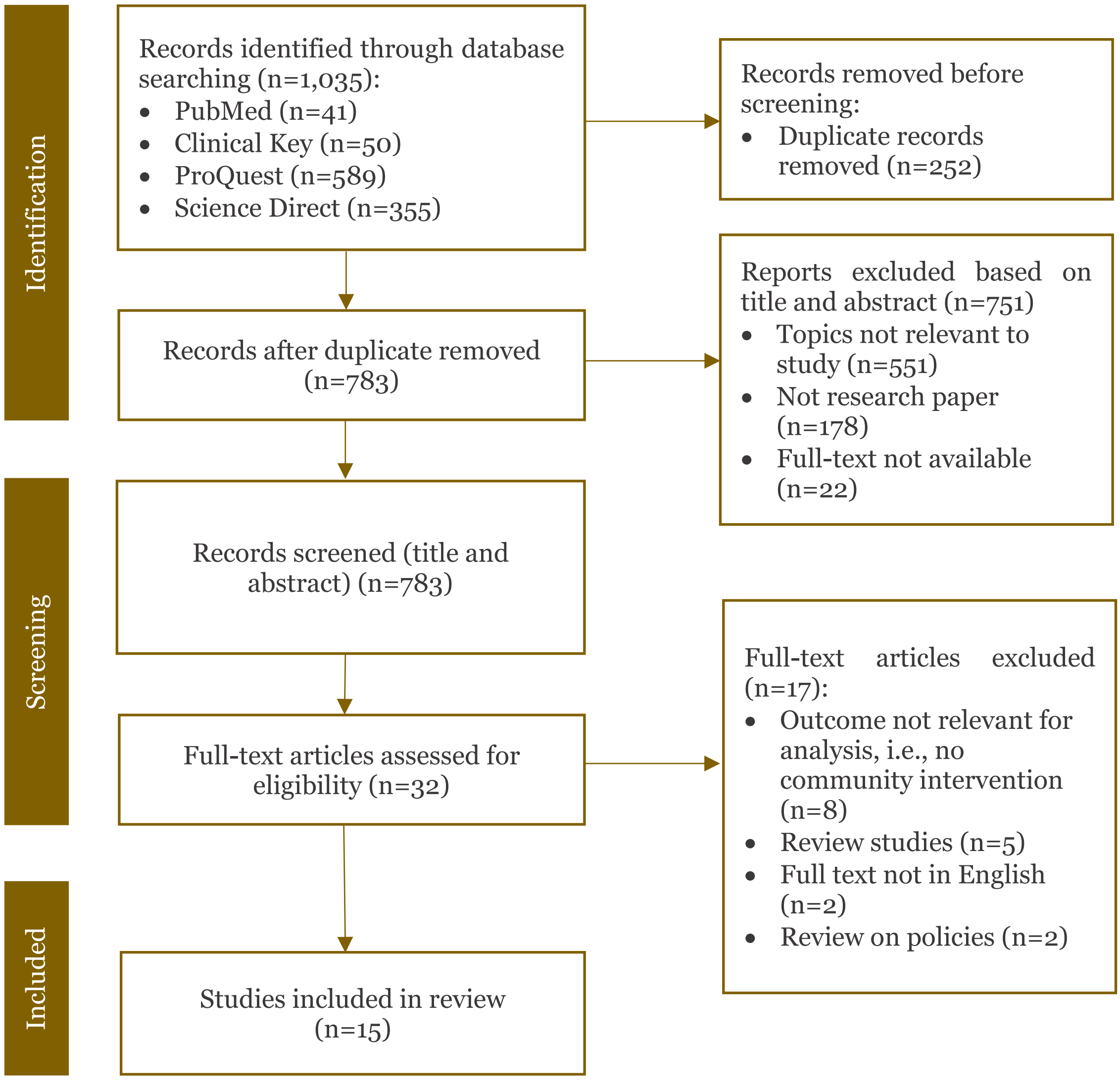

Figure 1. PRISMA flow diagram.

General study characteristics

All primary articles included were published from 2014 through 2023, as presented in **Table 1**. Most studies were conducted in America and Africa (40% each), while the rest were conducted in Asia and Australia (13.3% and 6.7%). Ten studies (66.7%) focused on the vector of dengue and other arboviruses, while five (33.3%) addressed the malaria vector. All studies used community interventions (**Table 2**); with seven designed as randomized control trials (RCTs) or cluster RCTs (46.7%), four as pre- and post-intervention surveys (24.7%), two as community-based implementation surveys (13.3%), one as a community-based implementation qualitative research and one as a pre- and post-intervention mix method study (6.7% each). Thirteen studies involved participants from the general community, two included school children, and only one specifically targeted government officials as respondents.

Interventions and outcome measures

Community intervention employed by most of the studies was community mobilization in modifying and eliminating vector breeding places and reducing larva and mosquito populations, except for ultra-low volume (ULV) spray intervention in one study, which had similar efficacy with community mobilization [13]. The subsequent most common intervention was community education and a campaign to raise awareness about the disease and the importance of vector control. All studies with community-driven vector control used a chemical-free approach except for one study that used ULV spraying [13]. Another study implemented *Bacillus thuringiensis israelensis* (*Bti*) as a form of biological control [21].

Table 1. Description of the included studies

Authors, year	Title	Country	Study periods	Journal name
Ndira *et al.*, 2014 [9]	Tackling malaria, village by village: A report on a concerted information intervention by medical students and the community in Mifumi, Eastern Uganda	Uganda (East Africa)	2007–2010	African Health Sciences
Healy *et al.*, 2014 [23]	Integrating the public in mosquito management: Active education by community peers can lead to significant reduction in peridomestic container mosquito habitats	New Jersey, USA (North America)	2009	PLoS One
Andersson *et al.*, 2015 [10]	Evidence-based community mobilization for dengue prevention in Nicaragua and Mexico (Camino Verde, the Green Way): Cluster randomized controlled trial	Mexico (North America) and Nicaragua (Central America)	August 2010 to January 2013	The British Medical Journal
Caprara *et al.*, 2015 [11]	Entomological impact and social participation in dengue control: A cluster randomized trial in Fortaleza, Brazil	Brazil (South America)	2012–2013	Transactions of the Royal Society of Tropical Medicine and Hygiene
Basso *et al.*, 2017 [12]	Scaling up of an innovative intervention to reduce risk of dengue, chikungunya, and Zika transmission in Uruguay in the framework of an intersectoral approach with and without community participation	Uruguay (South America)	April to November 2015	The American Journal of Tropical Medicine and Hygiene
Ingabire *et al.*, 2017 [21]	Community-based biological control of malaria mosquitoes using *Bacillus thuringiensis* var. *israelensis* (*Bti*) in Rwanda: Community awareness, acceptance and participation	Rwanda (East Africa)	February to July 2015	Malaria Journal
Mendoza-Cano *et al.*, 2017 [13]	Cost-effectiveness of the strategies to reduce the incidence of dengue in Colima, México	Mexico (North America)	February to August 2008	International Journal of Environmental Research and Public Health
Ouédraogo *et al.*, 2018 [22]	Evaluation of effectiveness of a community-based intervention for control of dengue virus vector, Ouagadougou, Burkina Faso	Burkina Faso (West Africa)	June to early October 2016	Emerging Infectious Diseases
Sulistyawati *et al.*, 2019 [14]	Dengue vector control through community empowerment: Lessons learned from a community-based study in Yogyakarta, Indonesia	Indonesia (Southeast Asia)	June to August 2014	International Journal of Environmental Research and Public Health
Kebede *et al.*, 2020 [15]	School-based social and behavior change communication (SBCC) advances community exposure to malaria messages, acceptance, and preventive practices in Ethiopia: A pre-posttest study	Ethiopia (East Africa)	2017–2019	PLoS One
McCann *et al.*, 2021 [16]	The effect of community-driven larval source management and house improvement on malaria transmission when added to the standard malaria control strategies in Malawi: A cluster-randomized controlled trial	Malawi (East Africa)	2015–2018	Malaria Journal
Gowelo *et al.*, 2023 [17]	Community participation in habitat management and larviciding for the control of malaria vectors in Southern Malawi	Malawi (East Africa)	April 2017 to May 2018	The American Journal of Tropical Medicine and Hygiene
Gopalan *et al.*, 2023 [18]	Community engagement to control dengue and other vector-borne diseases in Alappuzha municipality, Kerala, India	India (South Asia)	November 2016 to October 2018	Pathogens and Global Health
Martinez *et al.*, 2023 [19]	Community engagement to control dengue vector in two municipalities of Aragua State, Venezuela	Venezuela (South America)	May 2009 to November 2018	Journal of Current Health Sciences
Allen *et al.*, 2023 [20]	Factors influencing the community participation approaches used in *Aedes* mosquito management in the Torres Strait, Australia	Australia (Oceania)	August 2019 to July 2022	BMC Public Health

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Table 2. Study design, participants, intervention, disease focus, outcome measures, and results of the primary studies

Author	Type of research	Participants	Interventions	Focus of disease	Outcome measures	Outcomes
Ndira *et al.* [9]	Pre- and post-intervention survey and observation	General community	Community education via multimedia lectures by interdisciplinary teams (medical students, technology specialists, community)	Malaria	Use of previously distributed ITNs; malaria morbidity and mortality	Increase use of ITNs; decreased morbidity and mortality of malaria over the 3-year intervention period
Healy *et al.* [23]	Pre- and post-intervention survey and observation	General community	Community active education and community mobilization to reduce mosquito habitats	*Aedes*-borne diseases	Entomological indices; source reduction behavior	Reduced entomological indices; enhanced source reduction behavior in the treatment site
Anderson *et al.* [10]	Pragmatic open-label parallel group cluster RCT	Randomly selected residents/general community	Community mobilization protocol: community discussion, basic intervention chemical-free prevention, government dengue control program	Dengue	Self-reported cases of dengue; serological evidence of recent dengue infection; entomological indices	Fewer reports of dengue infection; lower risk of dengue cases; lower entomological indices
Caprara *et al.* [11]	Cluster RCT	General community, schoolchildren, and senior citizens	Community seminars; community involvement in clean-up initiatives; covering elevated bins and in-house trash disposal without larviciding; mobilizing. School children and seniors; and distribution of education materials	Dengue	Reduction of vector breeding places; economic consideration; entomological indices; community empowerment	The intervention package is effective compared with the routine control program in reducing vector breeding places; the costs of the intervention were reasonable; significantly reduced entomological indices; social participation, commitment, and leadership capacity vary between clusters; some were promising, and some were quite challenging
Basso *et al.* [12]	RCT	General community	Intervention by community participation in reducing vector habitats	Dengue	Entomological indices; community participation (handed bag back); Intervention costs; Acceptability of residents	Significantly larger decrease of entomological indices; increase of participation (increase handed back bag); reduction of intervention cost, yet increase dengue control cost compared with intervention without community participation; increase acceptability
Ingabine *et al.* [21]	Mixed method, pre- and post-intervention qualitative survey	Rice farmers	Community engagement activities *Bti* application in the rice fields and peri-domestic water dams	Malaria	Community perception towards *Bti* application in the rice fields	Positive inclination towards *Bti* application to reduce mosquito population in the area
Mendoza-Cano *et al.* [13]	RCT	General community	Intervention A: improving community participation in vector control; Intervention B: ULV spraying;	Dengue	Dengue cumulative incidence; DALYs; direct costs per intervention	Both interventions resulted in a similar reduction in the overall occurrence of dengue; Community participation

Author	Type of research	Participants	Interventions	Focus of disease	Outcome measures	Outcomes
			Interventions A and B: both interventions			improvement was more effective in reducing DALY; ULV spraying was the most efficient and effective treatment in vector control
Ouédraogo *et al.* [22]	RCT	Randomly selected general community	The eco-health intervention approach comprises pesticide-free dengue vector control and behavior change intervention through education	Dengue	Immunologic biomarker; Entomologic indices; KAP on dengue and prevention	Reduced exposure to *Aedes aegypti* mosquito bites in the intervention group; decreased entomologic indices; increased KAP
Sulistyawati *et al.* [14]	Cross-sectional survey on knowledge, attitude, practice (KAP) of dengue prevention, pre- and post-intervention control design.	General community	Control card feasibility study	Dengue	People's cleaning practice (perceived by field workers); entomological indices	The use of control cards resulted in minimal community involvement; entomological indices were not significantly different between the intervention and control group, pre-and post-treatment
Kebede *et al.* [15]	Pre-test and post-test study	School-based community: students and parents from primary schools	Exposure to malaria messages	Malaria	Comprehensive knowledge about malaria; risk perception and attitude; self-efficacy; community message acceptance; rational decision-making to adopt preventive practices; ITNs utilization; treatment-seeking	All indicators mainly increased after the intervention
McCann *et al.* [16]	Two-by-two factorial cluster RCT	General community	Community-driven approach, larval source management, housing improvement	Malaria	EIR; mosquito density, *Plasmodium falciparum* prevalence, and hemoglobin levels	EIR decreased; Mosquito density decreased; reduced *P. falciparum* prevalence and hemoglobin levels elevated
Gowelo *et al.* [17]	Cluster RCT	General community	Habitat management. larval source management (LSM), and larviciding alongside core vector control strategies	Malaria	Anopheline larval densities; Effectiveness of community-led LSM to reduce anopheline larval densities: Community's knowledge of malaria, its risk factors, and control methods	Reduced anopheline larval densities; the effectiveness of community-led LSM cannot be detected; increased knowledge of malaria, its risk factors, and control methods
Gopalan *et al.* [18]	Community-based implementation research	General community	Vector control (breeding reduction and anti-adult measures) and community mobilization	Japanese encephalitis and other *Aedes*-borne diseases	Entomological indices	Decrease in all indices after intervention

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Author	Type of research	Participants	Interventions	Focus of disease	Outcome measures	Outcomes
Martinez *et al.* [19]	Community-based implementation survey	General community	Community education through variable media and strategies.	Dengue	Entomological indices	Substantial decrease in all indices
Allen *et al.* [20]	Case study design incorporating multiple qualitative methods	Local government and state government agencies working in *Aedes* mosquito management	House inspections, awareness-raising campaigns, and community clean-up events	*Aedes*-borne diseases	Describe the community participation approaches used in the Torres Strait; examine the key factors influencing the choice of community participation approaches used in these programs	This study challenges the traditional top-down approach to mosquito management in high-income countries by examining community participation strategies in *Aedes* mosquito management and identifying opportunities to improve community participation in the region

Bti: *Bacillus thuringiensis israelensis;* DALYs: disability-adjusted life years; EIR: entomological inoculation rate; ITNs: insecticide-treated net; KAP: knowledge, attitude, and practice; LSM: larva source management; RCT: randomized controlled trial; ULV: ultra-low volume

Seven out of nine studies that focused on *Aedes* mosquitoes measured entomological indices such as house index, container index, and Breteau index [10-12,14,18,19,22,23]. One study assessed the cost-effectiveness of the intervention based on cumulative incidence and disability-adjusted life years (DALYs) [13], while another measured knowledge about dengue and self-reported preventive practice [22]. The cost was also a concern in two studies, in addition to other indicators [11,12].

Two of the four studies on malaria vector control assessed the use of insecticide-treated nets (ITNs) as an outcome measure [9,15], and two studies measured the community's comprehensive knowledge of the disease [15,17]. One study also emphasized community perception [21], as well as knowledge, attitude, and practice (KAP) concerning malaria vector control and the disease [15]. In contrast, the other studies assessed additional variables such as mosquito density, disease prevalence, entomological inoculation rate (EIR), and malaria morbidity and mortality [9,16,17].

Results of intervention

The results of the studies mainly reported positive outcomes following the intervention in malaria-focused studies. After receiving education, there was an increased in the use of ITNs [9,15] and improved the participants' perceptions, knowledge, attitudes, and practice [9,15,17,21]. Mosquito and larval densities were lower in two different studies [16,17]. Additionally, there was a notable decrease in malaria morbidity and mortality over the intervention period [9,16].

Similar outcomes were observed in dengue-focused studies. Several studies reported a significant decrease in entomological indices [10,11,18,19,22,23], with one study even finding a more significant decrease after community mobilization [12]. Nevertheless, one study revealed no significant distinction between the intervention and control groups after the treatment [14]. The same study also highlighted minimal community involvement in implementing the preventive approach outlined in the study.

In terms of community perception, most of the studies showed improved community perception towards implemented preventive approaches, both in malaria and dengue-focused studies [11,12,15,21], although one study found the results varied between clusters and groups [11]. A qualitative study in north islands in Australia found that while a government-led, top-down approach is typically preferred in high-income countries, a combination of top-down and bottom-up approaches holds promise in managing *Aedes* mosquitoes [20]. This approach considers the influence of regulatory, cognitive, and resource-related factors. Studies also found different results in terms of cost-effectiveness. The community participation approach was found to be more effective in reducing DALYs [13]. A study indicated that the cost of the intervention is relatively higher compared to the routine control program by the local government, yet it was considered reasonable [11]. Another study revealed the expenses associated with dengue control escalated when community involvement was present, in contrast to situations where it was not [12].

Discussion

The primary articles of this review demonstrate that community intervention was implemented in various ways. The community participated in breeding site management, habitat modification, active elimination of adult mosquitoes, housing improvement [10,12,16,17,23], and early detection of the infection [10,15,22]. Educational campaigns and active community involvement are advantageous in reducing habitats and controlling vectors [22,24].

An interesting outcome was revealed from the study in Yogyakarta, Indonesia, which found a gap between knowledge and practice in the community regarding dengue and its vector control [14]. The knowledge regarding basic dengue symptoms, preventive practices, and the *Aedes* mosquito's biting and breeding habits could have been improved despite discontinued campaigns. On the other hand, people's daily dengue preventive practices were generally commendable. This behavior resulted in low engagement in using the preventive activity checklist and no reduction in the vector population at the end of the intervention study. Therefore, this study concluded that solid motivation rather than knowledge is more important in influencing one's behavior [14].

Community education is a widely implemented endeavor aimed at increasing disease awareness and promoting a more substantial commitment to preventive measures [25]. The educators may include government or non-government workers, such as medical students and technology specialists [9], as well as community members, as demonstrated in a cluster RCT in Brazil and a study in suburban United States [11,23]. Community education occurs in various settings, including community events such as seminars and public discussions [10,11], one-on-one between educators and house residents [23], and through online platforms and multimedia [9].

Specific interventions were taken one step further by employing a citizen science approach in the IVM, particularly in mosquito surveillance. Citizen science is a feasible strategy for vector surveillance in resource-limited settings, as implemented in the Solomon Islands [26]. A similar approach was implemented in Rwanda, where volunteer citizens reported monthly mosquito data from handmade carbon dioxide (CO_2)-baited traps in their peri-domestic environments, as well as mosquito bites and household malaria cases [27]. In the current digital age, scientists and application developers have created programs supported by artificial intelligence (AI) that are believed to enhance public participation in providing real-time data, such as mosquito breeding sites, the presence of larvae or pupae and mosquito bites [28,29].

This review found that in one study, active education by community peers led to a significant reduction in artificial mosquito habitats [23]. This intervention yielded two distinct advantages. Firstly, education was delivered intensively through individualized interactions between educators and home residents. Secondly, the educators were community members, establishing a peer-to-peer dynamic. Peer education has demonstrated significant efficacy in other diseases' preventive approaches [30,31].

Program effectiveness is determined based on its outcome measures. The entomological indicators are likely the most straightforward outcome to evaluate, whereas behavior change poses a more significant challenge. Entomological indices of the *Aedes* mosquito include house index (HI), container index (CI), and Breteau index (BI), as introduced by WHO in 1997 [32]. These indices provide reliable information for an early warning system for vector-borne diseases [33], which assist in planning, management, and control of an outbreak situation [34,35].

Community intervention has been proven effective in reducing mosquito and larval densities in most studies, both in malaria and dengue-focused studies. The community takes action by implementing individual-level measures to mitigate risk, such as practicing mosquito bite avoidance, using insect repellents and physical barriers, and eliminating mosquito breeding and resting sites [36]. At the communal level, individuals can have a greater impact on reducing mosquito populations by implementing environmental modifications on a larger scale. Another example of environmental modification is housing improvement, which contributed to reducing indoor residual anopheline density and malaria transmission in Cameroon [37].

A systematic review found that health education interventions are successful and beneficial in sub-Saharan Africa community-based malaria prevention and control [38]. The health education programs successfully promoted reduced malaria morbidity and mortality among vulnerable individuals, enhanced malaria knowledge, and strengthened community-based malaria prevention and control efforts.

Nevertheless, to sustain gains, interventions must be based on mechanisms that facilitate long-term success [39]. Evidence demonstrates that educational intervention is efficacious in improving community behavior in mosquito-borne disease management [40]. Behavior change is crucial in maintaining the effectiveness of mosquito-borne disease elimination programs [41]. Studies that implemented interventions within three years or more demonstrated notable and long-lasting results in the indicators [10,16]. Another study indicates that although behavior change takes time and is challenging to attain, it guarantees sustainability once an individual adopts better practices [10].

People also change when the experience is meaningful and favorable. This condition is evident in the study in Rwanda, where *Bti* as biological control was applied in the rice fields [21]. Despite the new, unfamiliar intervention, farmers perceived it positively upon finding its impact on reducing mosquito density, which significantly reduced mosquito bites. On the contrary, a disparity in attitude and practice was identified in a study conducted in Curaçao (Dutch

Caribbean), where people showed a favorable disposition towards controlling mosquito breeding sites but displayed an unfavorable stance towards preventing mosquito bites [42]. People in that study expressed reluctance to wear protective clothing due to the inconvenience it caused, particularly in hot and humid weather. As a result, they rarely engaged in this practice despite being aware of its benefits.

Three studies also assessed the cost-effectiveness. Although the outcomes varied, the overall cost remained reasonably affordable [11-13]. Furthermore, community participation was seen as effective in reducing DALYs [13]. This result is consistent with research from Santiago de Cuba which demonstrated the cost-effectiveness of a participative, community-based *Aedes aegypti* control program compared to a vertical, government-led approach [43].

This study only used certain accessible databases, limiting the study findings' scope. Additionally, only a few studies from the last decade were included in the final review, reducing the full-scale effect of community intervention across different ages. Lastly, this study harnessed different outcome measures, leading to incomplete analysis without meta-analysis computation since it did not discriminate between the focus of disease (malaria and dengue), further expanding the range of outcome measures.

Conclusion

This review reveals that community interventions, consisting of community education and mobilization in vector and case surveillance, housing improvement, and environment modification, still play a pivotal role in determining mosquito-borne disease prevalence. The overall results of the primary studies showed a favorable inclination towards community intervention in managing mosquito vectors. Community interventions have successfully demonstrated effective mosquito control by increasing KAP, reducing vector populations, lowering disease incidents, and optimizing costs. Resource-limited settings can benefit from feasible, practical, well-planned, evidence-based, and community-based vector control interventions. To enhance motivation levels, it is necessary to implement bottom-up approaches that engage all community members in vector control, including those who do not currently adhere to recommended practices.

Ethics approval

Not required.

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

We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization, or manuscript preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or systems.

How to cite

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