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Effectiveness of family health education in malaria elimination programmes: a scoping review

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Abstract

Background Malaria remains a significant global health issue, with vector control strategies likes indoor residual spraying (IRS) and insecticide-treated nets (ITNs) show promise, socio-cultural and structural challenges often hinder their success. Family and community involvement, including individual adherence, household leadership, and participation by community leaders, are crucial in enhancing intervention outcomes. This review evaluates family health education's effectiveness in improving public health impact on malaria elimination programmes.

Methods A systematic review was conducted using Scopus, Web of Science, and PubMed, yielding 1,121 records through a predefined Population, Exposure, Outcome (PEO)-based search strategy. The review focused on studies published between 2019 and 2024 examining malaria elimination programmes and family health education. The Population consisted of families in malaria-endemic regions, particularly rural and urban areas of sub-Saharan Africa and Southeast Asia, including households with young children and pregnant women. The Exposure was participation in malaria elimination programmes, and the Outcome was the effectiveness of family health education in enhancing awareness, knowledge, and public health outcomes. Review articles, editorials, conference papers, and proceedings were excluded. Data extraction adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, and studies were appraised using the Mixed Methods Appraisal Tool (MMAT).

Results This study examines the effectiveness of malaria health education programmes using a socio-ecological framework, focusing on individual, family, and community-level influences. Twelve studies met the inclusion criteria, exploring interventions likes IRS and ITN across diverse populations. At the individual level, educational programmes significantly enhanced malaria knowledge and prevention behaviours. Within families, health education strengthened decision-making and reinforced preventive measures. At the community level, engagement in malaria-related initiatives improved collective action, though policy barriers limited widespread implementation. The review employed various research designs, underscore the role of multi-stakeholder involvement in ensuring the effectiveness of malaria elimination programmes.

Conclusion This study highlights the important of family structure in malaria elimination emphasizing maternal leadership in decision-making and health-seeking behaviours. Integrating family health education into public health strategies can enhance intervention effectiveness, improve adherence and promote long-term sustainability. Future

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programmes should leverage maternal influence and community engagement to strengthen malaria elimination programmes' efforts.

Keywords Malaria elimination, Family health education, Vector control, Community engagement, Public health intervention

Background

Family and community engagement plays a pivotal role in the success of malaria elimination programmes, which are often implemented at the household and community levels. These initiatives are typically structured around four key roles: individuals, household leaders, community leaders, and organizations, ensuring a holistic and collaborative approach to malaria prevention. Individual adherence to preventive measures, such as the use of insecticide-treated nets (ITNs), has a significant impact on outcomes [1]. Household leaders facilitate behaviour change within families, while community leaders mobilize resources and encourage participation, enhancing intervention uptake and sustainability [2, 3].

The outcomes of these multi-level roles are frequently measured using two key dimensions: family approach and public health impact. The family approach emphasizes improving household adherence, behaviour change, and education to ensure that preventive measures are effectively implemented [4]. The public health impact, on the other hand, looks at broader indicators like decreased malaria prevalence, improved health-seeking behaviour, and lower under-five mortality rates [5, 6].

Malaria elimination programmes require a comprehensive due to the complex interplay of factors influencing disease transmission and intervention effectiveness. The Socio-Ecological Model (SEM) provides a valuable framework for analysing these interactions by considering individual behaviours, family health education, community dynamics, and broader policy influence [7, 8]. This perspective enables a holistic understanding of how health education interventions operate at various levels of society, guiding the development of more targeted and effective malaria elimination programmes.

Within this multi-level context, the Family Systems Theory (FST) offers an additional lens by emphasizing the role of family units as interconnected systems where individual behaviours influence the entire household [9]. Given that malaria elimination programmes often rely on household adherence such as consistent use of insecticide-treated nets (ITNs) and timely treatment-seeking family dynamics play a crucial role in shaping health-seeking behaviours [4, 10].

For instance, parents or elders, as decision-makers, often model and reinforce behaviours that promote effective implementation of malaria elimination programmes [10]. Targeting family leaders through tailored education programmes can cascade these behaviours across household members, strengthening the impact of malaria intervention making them key targets for educational interventions that promote sustained adherence.

By integrating SEM and FST, malaria elimination programme can leverage both macro- and micro-level influences. While SEM highlights the broader environmental, social, and policy-related factors affecting malaria prevention, FST focuses on strengthening household-level engagement through participatory education approaches. Community-based education sessions and peer networks can be structured to align with family roles and communication patterns, fostering collective action and long-term adherence to prevention strategies. This combined approach enhances the reach and sustainability of malaria interventions by addressing both the structural and interpersonal determinants of health behaviour.

Malaria remains a major global public health challenge, with millions of cases reported annually, leading to significant morbidity and mortality [11]. Despite widespread implementation of evidence-based interventions such as insecticide-treated nets (ITNs), indoor residual spraying (IRS), and mass drug administration programmes achieving universal coverage and effective utilization remains difficult due to socio-cultural, behavioural, and structural constraints [5, 11, 12].

The effectiveness of malaria elimination programmes can be assessed through household adherence to ITNs and IRS, behaviour changes, and improved knowledge from education campaigns, which are crucial for ensuring long-term success in malaria prevention efforts. Studies show that ITN use can reduced malaria cases by 50% and reduce child deaths by 20% [5]. In sub-Saharan Africa, education programmes increased health-seeking behaviour by 40% [13]. Areas with high IRS coverage saw malaria rates drop by 30% compared to those with low coverage [14]. These results highlight the need for education and behaviour-focused strategies in malaria prevention.

However, knowledge gaps persist within communities, as many individuals recognize ITNs but remain unaware of other preventive measures [13–15]. Additionally, socioeconomic disparities influence malaria prevention adherence, highlighting the need for targeted and accessible education programmes to bridge these gaps [14, 16].

Family health education has emerged as a promising strategy to enhance prevention efforts by promoting adherence to ITNs and IRS, encouraging behavioural changes, and improving health-seeking behaviours. The success of malaria elimination programmes can be measured through increased household adoption of preventive measures, reduced malaria prevalence, and lower under-five mortality rates. Engaging families and community leaders fosters trust, addresses sociocultural barriers, and strengthens intervention effectiveness [17–19]. Training healthcare providers is equally essential, as enhanced training correlates with improved malaria detection and treatment, ultimately contributing to better public health outcomes [13–15].

A systematic review and meta-analysis underscored the impact of health education interventions in improving malaria knowledge and ITN usage. Theory-based approaches were particularly effective, with an odds ratio of 5.27 (95% CI 3.24 to 8.58, $p=0.05$) for ITN adoption, while malaria knowledge significantly improved with an odds ratio of 1.30 (95% CI 1.00 to 1.70, $p=0.05$) [14].

These findings underscore the importance of integrating behavioural models into malaria education programmes to ensure sustainable prevention efforts. This review evaluates the combined role of family health education and broader community involvement in improving public health outcomes within malaria elimination programmes. By leveraging a family approach, theory-driven interventions, and healthcare training, malaria education can become more impactful, ultimately shaping policies that foster long-term malaria elimination and public health improvements.

Methods

Research question formulation

This review investigates the research question: " How effective is family health education in enhancing public health outcomes in malaria elimination programmes?" The review employs the PEO framework (Population, Exposure, Outcome) to structure the research approach, ensuring a focused and comprehensive exploration of the topic.

a. **Population (P)** refers to Families and communities in malaria-endemic regions play a vital role in prevention and treatment. A *family* is a household unit (parents, children, and close relatives) responsible for health decisions and malaria prevention. A *community* consists of multiple households within a geographic area (e.g., village, neighbourhood) engaged in malaria elimination programmes. Family health education focuses on household-level interventions to change behaviours, while community health education includes broader initiatives like village-wide campaigns and mass media efforts.
b. **Exposure (E)** is Malaria elimination programmes (such as IRS, LLINs, ORS, Larvicides, MDA), The review examines how these malaria elimination programmes are integrated with family health education programmes, promoting awareness and encouraging behaviour change to improve adherence to preventive measures.
c. **Outcome (O)** It encompasses various aspects, including enhanced family health education, awareness, and knowledge on public health outcomes. It evaluates the review the improvement in community and family-level health education, increased awareness, and knowledge about malaria prevention, elimination and public health outcomes, including reduced malaria incidence, enhanced community participation in malaria elimination efforts, and a more informed population that can actively contribute to reducing malaria transmission.

In this scoping review, the PEO (Population, Exposure, Outcome) framework was selected over PICO (Population, Intervention, Comparison, Outcome) as it better aligns with our research focus on family health education in malaria elimination programmes. The PEO framework allows for a broader exploration of the impact of exposure to health education without requiring direct comparisons. Additionally, malaria elimination programmes is a complex, multifactorial process that extends beyond direct intervention comparisons, making PEO a more suitable approach for capturing these dynamics.

Data source and search strategy

Data for this review were sourced from three primary electronic databases: PubMed, Web of Science (WOS), and Scopus. These databases were selected for five (5) years publication period from 2019 to 2024 for their extensive coverage of relevant literature focusing on the malaria elimination programme, examining the impact the effectiveness of family health education in achieving improved public health outcomes research. The search strategy employed specific terms aligned with the PEO framework, according to Table 1.

Inclusion and exclusion criteria

The inclusion and exclusion criteria were carefully designed to ensure the relevance, quality, and originality of the studies reviewed. *Inclusion criteria* focused on original research articles and quantitative, qualitative and mixed-methods studies that directly explored the malaria elimination programmes and their impact on the effectiveness of family health

Table 1 Search Strategy

Databases	Search String
Pubmed	("community"[Title/Abstract] OR "family"[Title/Abstract] OR "vulnerable population"[Title/Abstract] OR "public"[Title/Abstract] OR "organisation"[Title/Abstract] OR "people"[Title/Abstract] OR "population"[Title/Abstract] OR "household member"[Title/Abstract] OR "malaria endemic regions"[Title/Abstract] OR "aborigin"[Title/Abstract] OR "indigenous"[Title/Abstract]) AND ("malaria program"[Title/Abstract] OR "ITN"[Title/Abstract] OR "LLIN"[Title/Abstract] OR "IRS"[Title/Abstract] OR "outdoor residual spraying"[Title/Abstract] OR "ORS"[Title/Abstract] OR "insecticide treated nets"[Title/Abstract] OR "malaria prevention"[Title/Abstract] OR "malaria interventions"[Title/Abstract] OR "integrated vector management"[Title/Abstract] OR "malaria elimination"[Title/Abstract] OR "malaria control"[Title/Abstract]) AND ("health literacy"[Title/Abstract] OR "health education"[Title/Abstract] OR "Training"[Title/Abstract] OR "workshops"[Title/Abstract] OR "health promotion"[Title/Abstract] OR "behavioral change"[Title/Abstract] OR "community engagement"[Title/Abstract] OR "skill development"[Title/Abstract] OR "awareness campaign"[Title/Abstract] OR "effectiveness"[Title/Abstract] OR "strategies"[Title/Abstract])
Web of Science (WOS)	TS = ("community" OR "family" OR "vulnerable population" OR "public" OR "organisation" OR "people" OR "population" OR "household member" OR "malaria endemic regions" OR "aborigin" OR "indigenous") AND TS = ("malaria program" OR "ITN" OR "LLIN" OR "IRS" OR "outdoor residual spraying" OR "ORS" OR "insecticide treated nets" OR "malaria prevention" OR "malaria interventions" OR "integrated vector management" OR "malaria elimination" OR "malaria control") AND TS = ("health literacy" OR "health education" OR "Training" OR "workshops" OR "health promotion" OR "behavioral change" OR "community engagement" OR "skill development" OR "awareness campaign" OR "effectiveness" OR "strategies")
Scopus	TITLE-ABS-KEY(("community" OR "family" OR "vulnerable population" OR "public" OR "organisation" OR "people" OR "population" OR "household member" OR "malaria endemic regions" OR "aborigin" OR "indigenous") AND ("malaria program" OR "ITN" OR "LLIN" OR "IRS" OR "outdoor residual spraying" OR "ORS" OR "insecticide treated nets" OR "malaria prevention" OR "malaria interventions" OR "integrated vector management" OR "malaria elimination" OR "malaria control") AND ("health literacy" OR "health education" OR "Training" OR "workshops" OR "health promotion" OR "behavioral change" OR "community engagement" OR "skill development" OR "awareness campaign" OR "effectiveness" OR "strategies"))

education in achieving improved public health outcomes. Studies were selected if they evaluated how malaria prevention efforts, such as ITNs, IRS, and community education, contributed to improving family awareness and health behaviours.

Additionally, articles were included if they reported measurable public health outcomes, such as reduced malaria incidence, increased community participation, and improved knowledge of malaria prevention strategies. This approach ensured a comprehensive understanding of the relationship between malaria elimination programmes and family health education in enhancing public health.

The *exclusion criteria* were established to maintain the quality and relevance of the studies included in the review. Review articles, editorials, conference proceedings, and grey literature were excluded, as they do not provide original empirical data or in-depth analysis of malaria elimination programmes. Additionally, studies that lacked primary research findings or did not specifically examine the relationship between malaria elimination programmes and family health education were not considered.

This ensured that the review focused on studies with strong methodological rigor, directly contributing to the understanding of how family health education enhances malaria prevention and public health outcomes. By narrowing the scope to empirical evidence and primary findings, the review ensured a robust and focused analysis of the research question.

Data extraction and synthesis

All authors (MHF, SEWP, MRAM, RS) independently extracted information from each article using a standardized Excel spreadsheet, which was subsequently reviewed by the first and second authors. The third and fourth authors provided additional insights and helped resolve any discrepancies identified during the review process.

Data extraction was guided by a standardized form designed to capture key details from each study, including study characteristics (e.g., authorship, year, location), design, sample characteristics, types of malaria elimination programmes, the subtheme, role level, and their outcome family health education and public health impact. This structured approach ensured consistent data collection across studies, enhancing the reliability and comparability of the extracted data.

Following data extraction, a narrative synthesis was conducted to examine how malaria elimination programmes contribute to improving family health education and public health outcomes. A thematic analysis was employed to systematically identify and compare findings across studies.

The synthesis process involved three key steps: first, identifying and coding key concepts from each study; second, grouping similar codes into overarching themes related to malaria elimination programmes and family health education; and third, performing a comparative analysis to assess common patterns and variations across different study contexts. This structured synthesis allowed for an in-depth understanding of the

effectiveness of malaria elimination programmes in enhancing family health education within affected communities.

Eligibility

The review selection process is illustrated in Fig. 1 using a PRISMA flow chart. A total of 1121 records were initially identified through comprehensive searches across three databases: Scopus, PubMed, and Web of Science. After removing 611 duplicate records, 510 studies were screened based on their titles and abstracts. This screening was independently conducted by two reviewers (MHF, SEWP, MRAM) using predefined inclusion and exclusion criteria.

At this stage, 470 records were excluded due to irrelevance to malaria elimination programmes, studies focusing on non-human populations such as animal research, and methodological misalignment with health-related topics. Additionally, studies with insufficient data reporting and duplicates not previously removed were also excluded leaving 40 articles for full-text eligibility assessment. The same two reviewers then evaluated the full-text articles to confirm their eligibility. Any disagreements were resolved through consultation with a third reviewer (RS) to ensure consensus.

This rigorous selection process resulted in 12 studies that fully met the inclusion criteria. The PRISMA flow diagram (see Fig. 1) was included as part of the quality appraisal phase, documenting excluded studies with

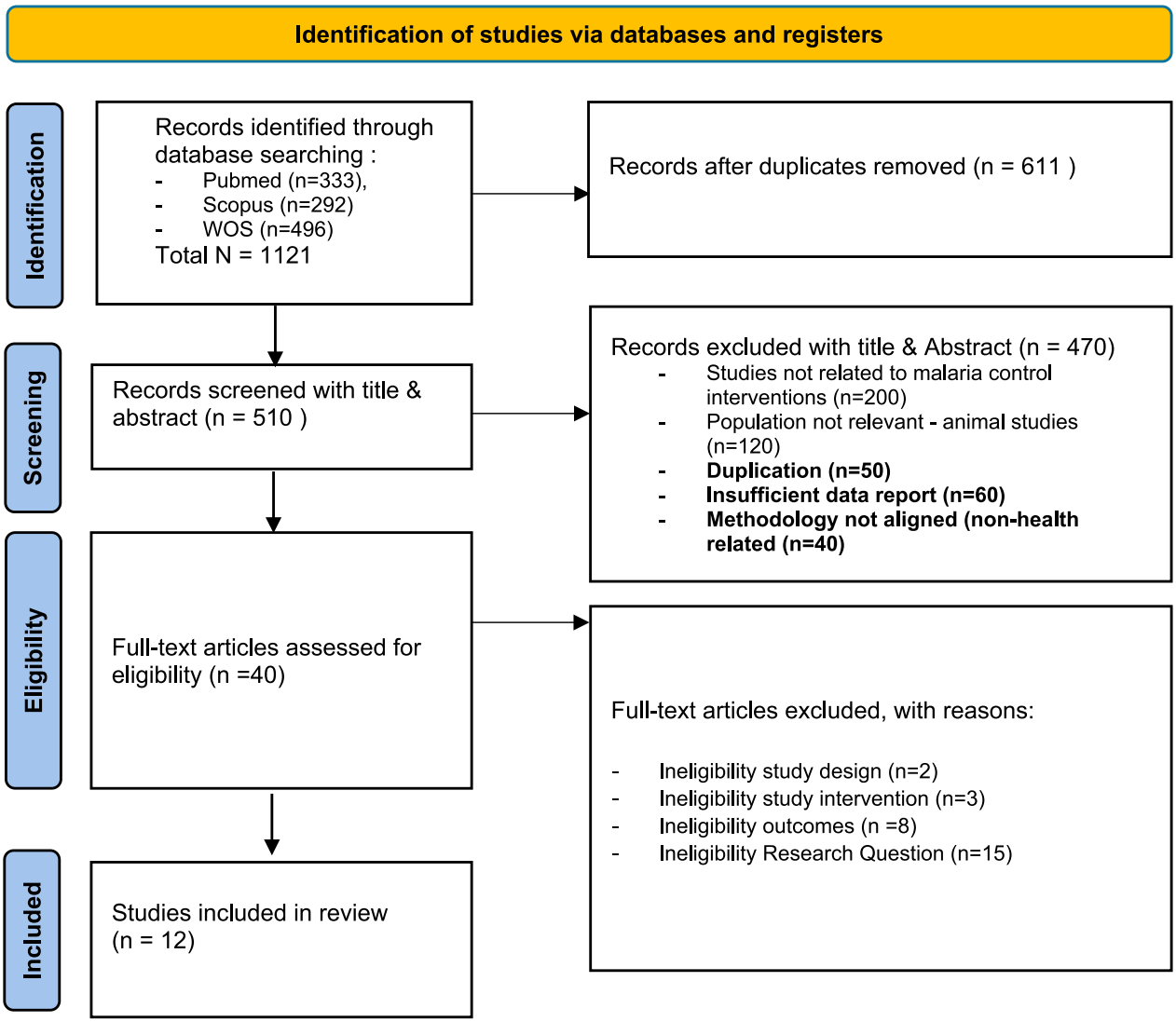

Fig. 1 Study selection process according to PRISMA flowchart

specific reasons for exclusion. This ensured transparency and accountability throughout the review selection process, aligning with the PRISMA 2020 guidelines.

Quality tool assessment

Quality appraisal of all studies was conducted by MRAM, MHF, SEWP, and RS using the Mixed Methods Appraisal Tool (MMAT). MMAT was chosen for its ability to evaluate diverse study designs, including qualitative, quantitative, and mixed-methods approaches. This tool ensured a rigorous assessment of methodological quality, applying criteria specific to each research design. By utilizing MMAT, the review upheld high standards of reliability and validity, leading to a comprehensive synthesis of findings from the 12 included studies. The quality assessment confirmed that all studies met the inclusion criteria, reinforcing the robustness of the review.

To minimize potential bias in study selection and data extraction, several strategies were implemented. An independent screening process was conducted, with at least two reviewers evaluating each study to ensure objectivity. Predefined inclusion criteria were applied to standardize study selection, and disagreements regarding eligibility were resolved through a consensus approach involving a third reviewer. Additionally, a thorough MMAT-based quality assessment was performed, further enhancing the reliability and validity of the findings. These measures ensured that the review process remained systematic, transparent, and free from selection bias.

Results

The characteristics of the studies

The findings from the twelve studies (12) based on Table 2 included in this review are divided into four categories: year of publication, study population, study design, and stakeholder roles in malaria elimination programmes.

Year of publication

The distribution of studies over time demonstrates a consistent interest in malaria elimination programmes research from 2019 to 2024. The majority of studies were published in 2020, accounting for 33.3% (n = 4). This was followed by 2019 and 2024, with 25% (n = 3) and 16.7% (n = 2), respectively. The years 2021 and 2022 had the least number of studies, contributing 16.7% (n = 2) and 8.3% (n = 1), respectively. The temporal distribution of studies highlights a continued focus on malaria elimination programmes, with a noticeable increase in recent years.

Study population

The studies included in this review targeted a wide range of populations, with an emphasis on adults. Adults made up the majority of the review population (83.3%; n = 10). This category was further broken down into three subcategories: pregnant women (16.7%, n = 2), the general population (41.7%, n = 5), and household (25%, n = 3). Children under the age of five were the subject of 16.7% (n = 2) of the studies. This distribution emphasizes the importance of malaria prevention in high-risk groups, particularly adults and vulnerable subpopulations like pregnant women and young children.

Study design

The review employed various research designs to explore their objectives. Qualitative studies constituted the highest proportion, representing 33.3% (n = 4). Mixed-methods and quasi-experimental studies each accounted for 25.0% (n = 3) of the total. Cross-sectional studies represented the smallest proportion, comprising 16.7% (n = 2). This diversity in study designs reflects a comprehensive approach to understanding the multifaceted dimensions of the research topic, combining qualitative insights with quantitative analysis.

The role of multi-stake holders based on the malaria elimination programme

Insecticide-treated nets (ITN)

a. **Individual Level**: Eight (8) studies (66.7%) reported on the effectiveness of ITN interventions in increasing usage among targeted populations. Additionally, six studies (50%) assessed the impact of ITN education programmes on improving individual knowledge regarding malaria prevention.
b. **Household Leader Level**: Five studies (41.7%) focused on the role of household leaders in promoting behavioural changes related to ITN usage within their household and communities.
c. **Community Leader Level**: Four studies (33.3%) highlighted the influence of community leaders in fostering engagement with ITN distribution initiatives and conducting awareness campaigns to promote their usage.

Long-lasting insecticidal nets (LLINs)

a. **Individual Level**: Behavioural changes related to the adoption of LLIN usage were examined in five studies (41.7%). These studies emphasized how individual

Table 2 Characteristics of the studies included

ID	Author/Year	Continent	Country/ Region	Sample Size	Population	Study Design	Types of Malaria Elimination Programmes	Outcome Measure Effectiveness(role level)			Key findings
								Individual	Household leader	Community leader	
1	Benito et al. (2024)	Africa	Malawi, Africa	96 caregivers (IDIs and Observation)	Under-5 children	Mixed-methods	ITN usage	Yes	Yes	No	ITN use among caregivers was influenced by accessibility and education level
2	Aongola et al. (2022)		Zambia, Africa	790 Zambian households (FDGs)	households at Luangwa District	Qualitative	IRS acceptability is influenced by timing	Yes	Yes	No	Community perceptions and timing influenced IRS acceptability
3	Odufuwa et al. (2020)		Tanzania, Africa	7,998 households	General population	Cross-sectional	ITNs, house modifications	Yes	Yes	No	House modifications and ITN use were key malaria prevention strategies
4	Abamecha et al. (2021)		Ethiopia, Africa	798 students	School children	Quasi-experimental	SBCC in schools	Yes	No	Yes	School-based SBCC programs improved malaria awareness among children
5	Galatas et al. (2021)		Mozambique, Africa	222 FGDs/SSIs	General population	Mixed-methods	MDA program	Yes	No	Yes	MDA program showed effectiveness in reducing malaria prevalence but had variable community adherence
6	Mensah & Anto (2020)		Mozambique, Africa	Surveys (IDIs) and Observations	Ghana households in in Sunyani West District	Mixed-methods	ITN ownership vs. usage gap	Yes	Yes	No	ITN ownership was high, but actual usage was inconsistent, highlighting the need for behavioral interventions
7	Fikrie et al. (2020)		Ethiopia, Africa	598 households	Households in Hawassa	Cross-sectional	ITNs, environmental management	Yes	Yes	No	Environmental management interventions, combined with ITNs, enhanced malaria prevention outcomes

Table 2 (continued)

ID	Author/Year	Continent	Country/ Region	Sample Size	Population	Study Design	Types of Malaria Elimination Programmes	Outcome Measure Effectiveness(role level)			Key findings
								Individual	Household leader	Community leader	
8	Aberese-Ako et al. (2019)		Ghana, Africa	74 IDIs, 64 Conversations, 8 Case Studies (ethnographic)	Pregnant women in Ghana	Qualitative	Family behavior influences LLIN use	Yes	Yes	No	Family behavior played a crucial role in influencing LLIN usage among pregnant women
9	Magaço et al. (2019)	Africa	Mozambique, Africa	413households & 61Interviews, 12 FGDs (urban and rural)	General population in Mozambique, Africa	Qualitative	IRS acceptance challenges	Yes	Yes	No	IRS acceptance was challenged by misconceptions and logistical issues in urban and rural areas
10	Samsudin et al. (2024)	Asian	Malaysia	267 individuals – FGDs and IDIs	Orang Asli communities, Malaysia	Qualitative	ITN Education and socio-economic factors	Yes	No	No	ITN education and socioeconomic factors significantly impacted ITN adoption in Orang Asli communities
11	Kumar et al. (2020)		Pakistan	200 pregnant women	General population Remote areas in Pakistan	Quasi-experimental	LLIN education	Yes	Yes	No	LLIN education programs improved knowledge but required reinforcement for sustained behavioral change
12	Ghahremani et al. (2019)		Iran	172 Suburban housewives	General Population in Iran	Quasi-experimental	PRECEDE model education ITN	Yes	Yes	No	The PRECEDE model-based ITN education was effective in increasing ITN adoption among suburban housewives

behaviour contributes to enhanced household practices in malaria prevention.

b. **Household Leader Level**: Four studies (33.3%) emphasized the role of household leaders in fostering community engagement and participation in LLIN distribution programmes, showcasing their influence on uptake and awareness.

Indoor residual spraying (IRS)

Community Leader Level: Three studies (25%) evaluated the effectiveness of IRS campaigns led by community leaders in increasing community awareness and participation in malaria elimination programmes. Furthermore, two studies (16.7%) explored the role of community leaders in facilitating IRS implementation and promoting its benefits, particularly in terms of enhancing acceptance and coverage.

Figure 2 presents the geographic distribution of studies included in this review, categorized by country and continent. The African region dominates the analysis, contributing 75% (9 studies) of the total. Mozambique emerges as the leading contributor with 25%, followed by Ethiopia with 16.7%. Other African nations, including Ghana, Malawi, Tanzania, and Zambia, each account for 8.3% (1 study), emphasizing the region's critical focus on malaria research due to its significant disease burden.

In comparison, the Asian region contributes 25% (3 studies) overall. Malaysia, Pakistan, and Iran each represent 8.3% (1 study). This highlights focused efforts within Asia to address malaria, concentrating on unique regional challenges and tailored elimination programmes. Table 3 highlights the roles of various family and community levels in influencing the impact of malaria elimination strategies through the family and public health outcomes.

At the **individual level**, interventions focused on ITN ownership and usage demonstrated significant improvements. For instance, ITN ownership was reported at 78.93%, while usage reached 55.93%, with barriers such as discomfort (23%) and low perceived malaria risk (30%) identified. Despite a 40% increase in ITN compliance following LLIN education, significant barriers persist, with cultural misconceptions accounting for 25% of the challenges.

Socioeconomic constraints, geographic inaccessibility, and mistrust in health interventions further hinder widespread adoption. Addressing these issues requires community-led initiatives to build trust, culturally tailored education campaigns, and improved distribution networks. These strategies have proven effective in strengthening community engagement, enhancing ITN adherence, and ultimately reducing malaria incidence.

At the **household leader level**, educational campaigns on ITN usage led to a 75% increase in coverage among families, which significantly reduced under-five malaria incidence by 50%. Additionally, interventions based on the PRECEDE model improved knowledge by 85%, with ITN usage rising from 45 to 72% post-intervention. Urban-specific programmes targeting ITNs and house modifications enhanced adherence, with urban areas reporting a higher usage rate (65%) compared to rural areas (35%).

The **community leader level** also played a pivotal role, particularly through Social and Behaviour Change Communication (SBCC) in schools, which increased ITN usage and malaria awareness by 70% among students and families. Community-led Mass Drug Administrative (MDA) programmes incorporating LLIN, rapid diagnostic tests, and treatment strategies achieved 87% acceptability and reduced malaria prevalence by 58–73% across household. These outcomes underscore the importance of community engagement in driving behavioural change and improving health outcomes.

Table 4 explores the role of families in malaria elimination programmes, emphasizing qualitative insights. **ITN usage** revealed gaps in effectiveness due to challenges in usability, as families often struggled to hang and use nets properly. Educational campaigns were instrumental in bridging the ownership-utilization gap, with families reporting increased understanding and compliance after realizing the benefits.

Indoor Residual Spraying programmes faced acceptance barriers linked to economic and cultural factors. Community insights highlighted the role of unemployment in positively influencing acceptability due to increased availability, while trust issues with IRS chemicals hindered coverage. Policy adaptations are recommended to address these cultural and logistical barriers.

Mass Drug Administrative (MDA) programmes were hindered by absenteeism caused by work commitments, despite showing high community acceptability. Similarly, family behaviour significantly influenced LLIN adherence, with socio-cultural dynamics playing a pivotal role. For instance, families felt safer when male household members endorsed LLIN use.

Discussion

The effectiveness of malaria education interventions depends on multiple factors, including socio-cultural contexts, geographic settings, and levels of malaria transmission. The Family Systems Theory (FST) framework underscores the role of family dynamics in influencing health behaviours. Household-level engagement is crucial for promoting the uptake of malaria prevention measures such as ITNs and IRS. Families with a strong emphasis

on collective decision-making often demonstrate better adherence to malaria elimination programmes [20, 21].

Urban vs. rural settings

The setting in which a family resides significantly influences the effectiveness of malaria education. Urban areas typically benefit from greater access to healthcare services, higher literacy levels, and increased exposure to public health campaigns [22]. However, urban populations may exhibit lower risk perception due to reduced exposure to malaria vectors. Conversely, rural areas experience higher malaria burdens but often face barriers such as limited healthcare access, lower literacy levels, and socio-economic constraints [23, 24].

Another critical factor in malaria education effectiveness is the intensity of malaria transmission in a given region. High-transmission areas require sustained behavioural interventions, as the constant exposure to malaria vectors necessitates ongoing prevention and treatment efforts [25, 26]. Education programmes should emphasize long-term prevention strategies and address potential issues of intervention fatigue.

In contrast, low-transmission areas may struggle with complacency, where reduced perceived risk leads to lower adherence to preventive measures. Strategic messaging in these regions should highlight the importance of sustained vigilance despite lower incidence rates. Effective malaria education strategies must be tailored to address these differences, ensuring accessibility and relevance across diverse settings [27].

Trends in malaria research and public health implications

The effectiveness of malaria education interventions has evolved, with notable peaks in research activity. A significant surge in malaria-related studies in 2020 may be linked to global health initiatives during the COVID-19 pandemic, which heightened awareness of infectious diseases and spurred increased research funding [28, 29].

This highlights the importance of global health crises in shaping research priorities and resource allocation. Understanding these trends provides insight into how external factors influence the development and dissemination of malaria education programmes [11].

Comparative analysis of African and Asian regions

Regional differences play a crucial role in malaria elimination programmes effectiveness. A comparison between African and Asian regions reveals variations in public health infrastructure, implementation strategies, and community engagement. African countries, with higher malaria burdens, often emphasize widespread distribution of preventive tools such as ITNs and IRS, whereas Asian countries may focus on targeted vector control and integrated health education programmes [5, 7].

Socio-cultural differences, such as variations in healthcare-seeking behaviours and community trust in health interventions, further impact the success of malaria education. These differences underscore the need for context-specific education approaches tailored to regional needs and challenges.

The role of socio-ecological model every level

Malaria elimination programmes are most effective when tailored to the specific contexts and needs of different populations. This review adopts the socio-ecological model (SEM) to provide a structured framework for addressing gaps in malaria elimination programmes efforts at multiple levels: individual, family, community, and policy in Fig. 3 [7].

The SEM highlights that health outcomes, including malaria prevention and the reduction of morbidity and mortality, are shaped by factors at multiple levels. Interventions that address these levels in a coordinated manner can significantly enhance the overall effectiveness of malaria elimination programmes efforts.

At **the individual level**, the effectiveness of malaria elimination programme measures such as insecticide-treated nets (ITNs) and indoor residual spraying (IRS) can be directly influenced by behaviour change campaigns and culturally sensitive education programmes. These interventions aim to increase knowledge, and misconceptions, and promote preventive behaviours. The effectiveness of these measures can be measured through indicators such as the adoption rate of ITNs, IRS participation, and proper usage rates. For example, studies have shown that culturally tailored educational campaigns can significantly improve ITN compliance by increasing understanding of the importance and correct usage of these tools [30, 31].

Tracking the incidence of malaria cases and reductions in mosquito bites following the introduction of these interventions serves as a clear metric of their effectiveness [11]. Advances in technology, such as the use of drones for larval source management and genetic modification of mosquitoes, are emerging as additional tools for malaria elimination programmes and warrant further exploration in policy and practice.

At the family level, interventions can be strengthened by recognizing the influence of family structures on malaria prevention, as explained by Family Systems Theory (FST)**.** FST suggests that families function as interconnected units, where changes in one member's behaviour can influence the entire household [32]. Applying this perspective, **patriarchal and matriarchal family systems** shape decision-making, health-seeking

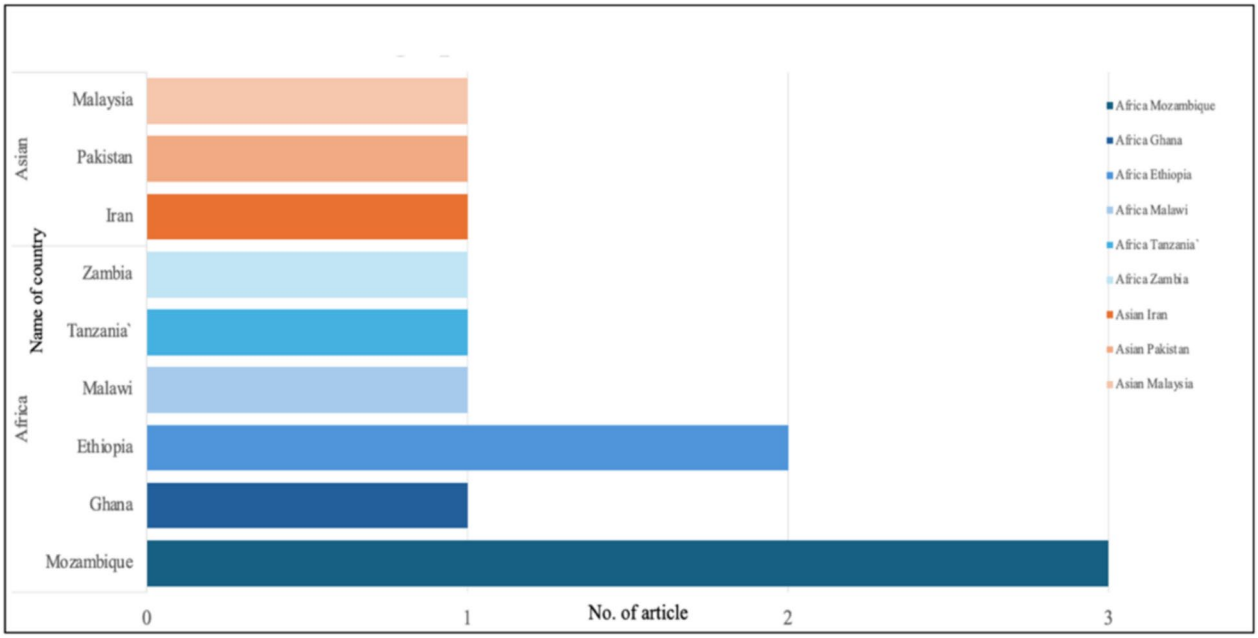

Fig. 2 The geographical distribution of studies included

behaviours, and resource allocation, directly affecting malaria prevention efforts [13, 16].

This study highlights the significant role of matriarchal families, where mothers, as primary caregivers, serve as role models in shaping health behaviours. Within the FST framework, maternal influence extends beyond individual decision-making to the collective adoption of malaria prevention practices, ensuring better adherence to ITN use, IRS implementation, and treatment-seeking behaviours. Women's active role in **health education** strengthens malaria elimination programmes efforts by fostering sustained preventive behaviours within the family system (Additional file 1,2,3,4).

By involving household leaders in malaria prevention through family health education and financial incentives (e.g., subsidies for ITNs or IRS services), interventions can align with FST principles, reinforcing the interconnected nature of family health decisions. Studies have demonstrated that family health education leads to higher ITN usage and IRS participation further supported by Aberese-Ako et al. and Odufuwa et al. [33, 34].

Measuring the effectiveness of these interventions through family-level surveys and household malaria incidence rates can provide further insights. While patriarchal structures also play a role, FST suggests that matriarchal leadership fosters a more consistent, behaviour-driven approach**,** reinforcing the need for interventions that leverage maternal influence for long-term public health benefits**.** Beyond the family unit, the collective influence of households within a community plays a crucial role in malaria prevention, necessitating the engagement of trusted leaders and broader awareness initiatives.

At the community level, engaging trusted leaders and implementing school-based awareness campaigns fostered collective action and increased acceptance of malaria interventions. Addressing gaps such as inequitable resource distribution and insufficient monitoring systems at the policy level emphasized the importance of equitable policies, strengthened health infrastructure, and integrated real-time surveillance. This multi-level approach ensures context-specific, sustainable strategies for effective malaria elimination programmes [35].

Barriers to community-led malaria elimination programmes

Despite the documented success of community-led interventions in malaria elimination programmes, several critical barriers persist. **Cultural beliefs and misconceptions** remain significant hurdles. In certain communities, traditional healing practices are preferred over modern interventions such as ITNs or IRS. This cultural resistance is often rooted in long-standing practices and mistrust in biomedical approaches, particularly where prior health programmes have failed to engage community values [13, 20, 28].

In addition, **financial constraints** impede the continuity and scale of community-based malaria

Table 3 Role of family health education on public health impact based on quantitative studies included

Author/Year	Theme	Sub-Theme Role Level	Types of Malaria Elimination Programmes	Key Findings	Outcome/Impact	
					Family Approach Outcome	Public Health Impact
(Mensah & Anto 2020)	Behavioral Change and Knowledge Transfer	Individual	ITN ownership vs. usage gap	ITN ownership: 78.93%ITN usage: 55.93%. Barriers: discomfort (23%)Perception of low malaria risk (30%)	Targeted education reduces usage gap such as campaign	Malaria prevalence ↓
(Ghahremani et al. 2019)		Household Leader	PRECEDE model education ITN	Knowledge improved by 85%ITN usage from 45 to 72% post-intervention. Behavior change was significant	Structured education boosts adherence of ITN	Malaria Prevalence ↓ 50%
(Benito et al. 2024)	Leadership and Community Engagement	Household Leader	ITN usage	ITN ownership: 78.93% (✓)	Behavior change needed to improve ITN use	Malaria incidence ↓ Under-five 50%
(Abamecha et al. 2021)		Household leader and Community leader	School-based educationof ITN	↑ Education ITN usage and malaria knowledge by 70%	Early education fosters long-term behavior change	Early education fosters long-term behavior change. Higher household ITN adoption
(Galatas et al. 2021)		Community leader	Mass Drug Administration (MDA)	Acceptability: 87%. **Barriers:** Absenteeism (20%)Rumors (15%)	Community education is key for MDA success	Malaria Prevalence ↓ (58–73%
(Kumar et al. 2020)	Structural and Resource-Based Barriers	Individual and Household leader	LLIN education	LLIN compliance ↑ by 40%Cultural barriers: misconceptions: 25%	↑ compliance in individual and family	Malaria incidence ↓ by 35%
(Odufuwa et al. 2020)		Household Leader	Home modification education ITN	Urban ITN usage: 65%, Rural areas: 35%	Home modifications complement ITN strategies	↓ mosquito entry & ↓ malaria rates
(Fikrie et al. 2020)		Household Leader	Environmental management and ITN	Urban ITN usage: 65%rural areas: 35%	Better protection among educated families	Malaria prevalence ↓

↑ = Increased/High, ↓ = Reduced/low

Table 4 Role of family in the malaria control program based on qualitative study included

Author/Year	Theme	Family role	Key Insight	Implications for Malaria Control
(Benito et al. 2024)	ITN Education	Family influence on ITN use	ITNs seen as effective but usability concerns exist	Challenges in ITN usability highlight the need for tailored support
(Samsudin et al. 2024)		Economic impact on ITN use	ITN education increased preventive practices	Incentives increase ITN adoption
(Mensah & Anto 2020)		ITN ownership vs. usage gap	Education improved adherence	Bridging knowledge gaps boosts ITN use
Aongola et al. 2022	IRS Acceptance	IRS acceptability	Economic & timing barriers exist	Policies should address financial and logistical issues.
Magaço et al. (2019)		IRS misconceptions	IRS acceptance challenges hindered initial coverage	Community trust-building is required
(Galatas et al. 2021)	Behavioral Change Strategies	MDA adherence barriers	Absenteeism affected uptake	Flexible scheduling can improve participation
(Aberese-Ako et al. 2019)		Gender roles in ITN use	Men's encouragement improved compliance	Gender-based approaches enhance prevention

programmes. Sustaining community engagement, training community health workers, and running public education campaigns require consistent funding, which is often lacking in low-resource settings. These limitations hinder the implementation of long-term behaviour change strategies essential for malaria elimination [11].

Trust in government health authorities also undermines participation in malaria interventions. Community engagement tends to be low in regions where people perceive health programmes as externally imposed or politically motivated. This underscores the need for participatory, inclusive policy-making that involves community leaders and acknowledges local knowledge [13].

Furthermore, operational barriers such as inadequate logistical support, limited access to quality healthcare, and insufficient monitoring mechanisms reduce the effectiveness of community-led efforts. Without supportive infrastructure, even well-designed interventions may struggle to produce sustainable outcomes.

Policy implication across regions

Tailoring malaria policies to reflect regional socio-cultural and epidemiological contexts is crucial. **In high-transmission areas,** such as Sub-Saharan Africa, robust surveillance systems and integration of community health workers into national malaria programmes have shown promise. For example, Uganda's decentralized malaria surveillance allows for rapid detection and targeted responses, improving outbreak containment [36, 37].

In low-transmission settings, sustaining elimination requires vigilance. Countries like Sri Lanka and El Salvador have demonstrated the effectiveness of integrated strategies, combining vector control with education, case management, and community empowerment. Embedding malaria education into maternal and child health services and school-based initiatives can ensure continuous public awareness even in areas with declining incidence [11, 15, 38].

Several Southeast Asian countries offer valuable insights. In Cambodia, the Malaria Elimination Action Framework effectively integrated malaria and dengue prevention efforts by utilizing a community-based platform. This approach allowed for more efficient resource use and fostered stronger community ownership and engagement in disease control activities. Vietnam's use of Village Health Collaboratives highlights how local volunteers can successfully deliver interventions, distribute treatment, and track outcomes, fostering trust and participation [11, 39].

Additionally, digital health innovations hold potential. Rwanda's use of mobile technology for real-time malaria reporting and case tracking has improved response times and data quality, demonstrating the value of mHealth tools in resource-limited settings [40].

Ultimately, strengthening policy frameworks to support local ownership, cultural adaptation, cross-sector collaboration, and sustainable funding mechanisms is critical. Empowering communities not only increases the efficacy of malaria elimination programmes but also fosters resilience and long-term public health gains, and insufficient monitoring mechanisms reduce the effectiveness of community-led efforts. Without supportive infrastructure, even well-designed interventions may struggle to produce sustainable outcomes.

Malaysian perspective and strategies

In the Malaysian context, despite the country's status as a middle-income nation with advanced health systems,

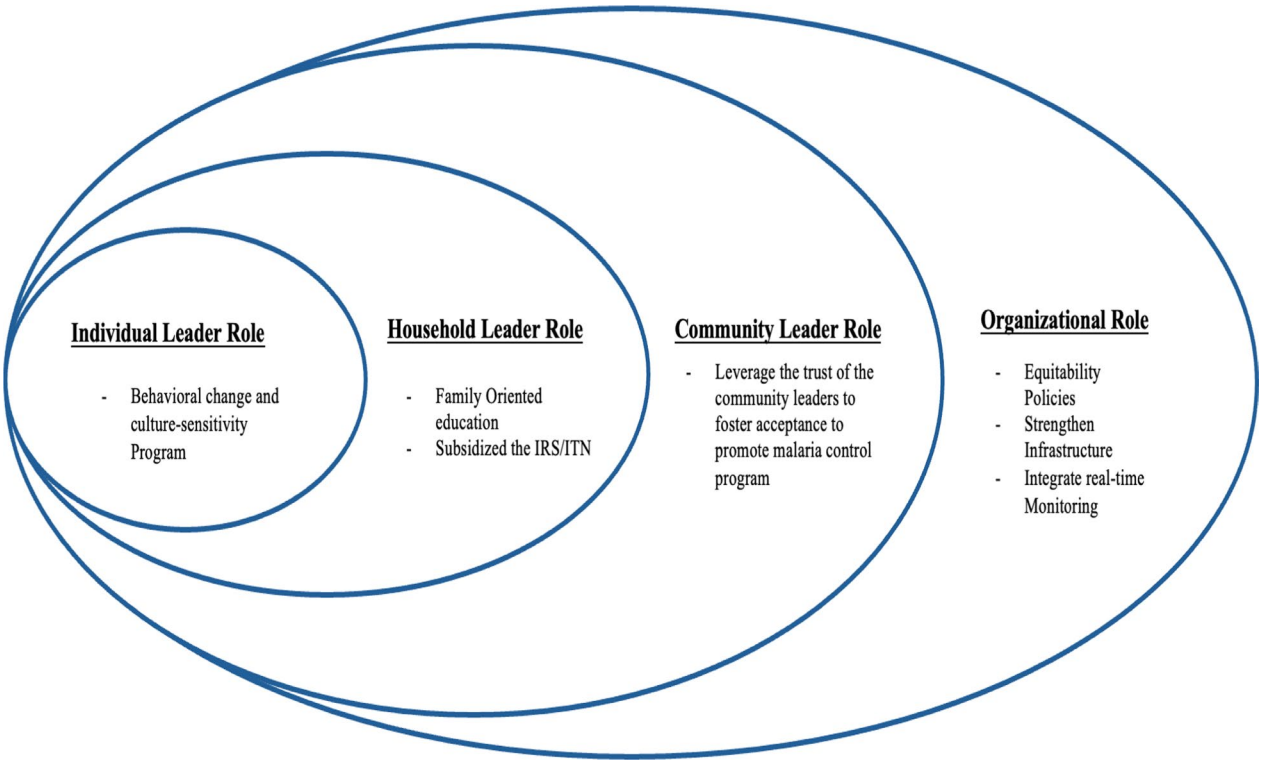

Fig. 3 Identifying multi-level gaps in malaria control; a socio-ecological model approach

malaria persists as a public health challenge, particularly among high-risk populations such as the Orang Asli in Peninsular Malaysia and indigenous communities in Sabah and Sarawak. These groups face heightened vulnerability due to their proximity to forested areas and their reliance on forest resources, which increases their exposure to zoonotic malaria caused by *Plasmodium knowlesi* [15, 41].

Unlike other regions where malaria is primarily human-to-human, Malaysia's unique epidemiology involves transmission from wildlife reservoirs, particularly macaques, through mosquito vectors. This distinct ecological dynamic poses additional challenges to control efforts [15, 41].

At the individual level, culturally tailored health education programmes focusing on zoonotic malaria prevention are vital. Behaviour change campaigns should address misconceptions about malaria transmission, particularly its zoonotic origins, and promote preventive measures like insecticide-treated nets (ITNs) and indoor residual spraying (IRS) adherence. Studies in Malaysia highlight that community-specific education, especially in Orang Asli settlements with limited awareness of zoonotic malaria, significantly improves the adoption of preventive practices [15, 41].

At the family level, involving household leaders in malaria prevention interventions is key, particularly in Orang Asli and Bornean communities, where communal living and decision-making are central. Due to logistical challenges and the rural nature of these areas, community leadership structures in Sabah and Sarawak play a critical role in malaria case detection and surveillance. Strengthening these leaders' capacity to advocate for and implement malaria elimination programme measures can greatly enhance the reach and effectiveness of interventions. Successful models from African countries, where empowering household leaders has proven effective, offer lessons that can be adapted to Malaysia's context [33, 34].

However, barriers persist in the implementation of malaria elimination programmes measures. The long-term sustainability of IRS acceptability relies on whether positive perceptions persist beyond the intervention period. Follow-up studies assessing community attitudes months or years after implementation provide insights into acceptance trends and continued usage [42]. However, Cultural beliefs, such as fears surrounding the IRS chemical safety, absenteeism from community programmes due to competing priorities, and mistrust of health interventions, pose significant challenges [43, 44].

Addressing these requires integrating culturally sensitive education campaigns, fostering trust through

community leadership, and designing strategies that account for socio-cultural dynamics and structural constraints. By leveraging the Socio-ecological model framework, this study underscores the interconnected nature of individual, family, community, and policy roles in malaria elimination programmes, ensuring long-term public health outcomes [42, 45].

The effectiveness of malaria education depends on geographic, socio-cultural, and economic factors. Urban areas benefit from better healthcare and literacy but may have lower risk perception, while rural areas face higher malaria burdens with limited resources [14, 44, 46]. High-transmission regions need sustained interventions, while low-transmission areas risk complacency. Socio-cultural factors like income, beliefs, and gender roles influence intervention success.

Tailored strategies, such as digital campaigns in urban areas and community-led programmes in rural settings, enhance impact. High-transmission areas require reinforcement efforts, whereas low-transmission regions need vigilance messaging to prevent resurgence, ensuring malaria education remains accessible and effective across diverse setting.

Integrating interventions across individual, household, community, and policy levels creates a synergistic effect, leading to significant public health impacts. For instance, a 78.93% ITN ownership rate improved to 55.93% consistent usage through community campaigns, while family-centred education programmes reduced under-five malaria incidence by 50% [32, 47]. These outcomes emphasize the importance of designing context-specific and culturally sensitive interventions to foster sustainable behavioural changes and achieve long-term reductions in malaria morbidity and mortality.

Recent technological advancements, such as the use of drones for malaria vector control, have shown promising results in targeted larvicide applications and environmental surveillance. Drones provide a cost-effective means of reaching remote and difficult-to-access areas, improving mosquito control efforts by identifying breeding sites and directly delivering insecticides [35].

In Malaysia, integrating drone-based vector control into malaria surveillance programmes, particularly in forested regions where human access is limited, could enhance the effectiveness of intervention strategies. Additionally, artificial intelligence-driven predictive modelling, combined with drone mapping, can optimize malaria hotspot identification, enabling proactive intervention planning [48, 49]. Genetic modification of mosquitoes, such as gene drive technology, is another emerging approach that has been explored to suppress malaria vector populations and reduce transmission rates [49].

At the policy level, addressing inequities in resource distribution and integrating real-time surveillance can optimize malaria elimination programmes. Strengthening health infrastructure with data-driven monitoring systems ensures efficient allocation of intervention resources. Recommendations for Malaysia's malaria elimination policies include prioritizing equitable resource distribution, expanding health education programmes, and leveraging technological advancements such as drone surveillance and genetically modified mosquitoes to complement traditional vector control methods. Additionally, aligning national malaria strategies with WHO guidelines can enhance global cooperation and effectiveness.

To enhance the clarity of the discussion, a visual representation of the SEM framework applied to malaria elimination programmes, along with a summary of the interconnected roles at each level, is recommended. This would help illustrate the multi-faceted approach required for effective malaria intervention. Future efforts should focus on overcoming persistent barriers, such as cultural misconceptions about IRS and competing priorities, through the integration of behavioural change theories and tailored strategies. Sustained community engagement, led by trusted figures, is crucial for fostering long-term behaviour change and ensuring the lasting impact of malaria elimination programmes.

Strengths and limitations

This study's strength lies in its adopted application of the socio-ecological model, which offers a comprehensive framework for addressing malaria elimination programmes across individual, family, community, and policy levels. By emphasizing the interconnected roles at these levels, the review provides a clear structure for designing tailored interventions.

Another significant strength is the focus on evidence-based strategies, such as family-centred education and community-led initiatives, which have been shown to improve ITN compliance and increase malaria knowledge. Additionally, the review's emphasis on culturally sensitive approaches through behavioural change campaigns and locally adapted education programmes underscores its relevance in diverse socio-cultural settings, increasing the likelihood of intervention success.

However, some limitations must be acknowledged. The findings may be constrained to the specific socio-cultural and geographical context of the review, which limits their applicability to regions with differing malaria transmission patterns. The findings may be constrained by the specific socio-cultural and geographical contexts of the reviewed studies, which could limit their applicability to regions with differing malaria transmission patterns.

A key limitation is the regional bias, as the majority of included studies focus on Africa due to the region's high malaria burden. While this emphasis is justified, it restricts the generalizability of the findings to other malaria-endemic areas, such as Southeast Asia and the Americas, where distinct contextual factors may influence intervention effectiveness. Future research should expand the geographical scope to provide a more comprehensive understanding of family health education's impact in diverse settings.

Cultural and behavioural barriers also pose significant challenges to malaria elimination programmes. Concerns over the safety of indoor residual spraying (IRS), mistrust of health interventions, and competing household priorities contribute to low participation in community-based programmes [43, 44]. Addressing these issues requires the integration of culturally sensitive education campaigns, fostering trust through community leadership, and designing interventions that consider socio-cultural dynamics and structural constraints.

By leveraging the Socio-Ecological Model, this study underscores the interconnected nature of individual, family, community, and policy roles in malaria elimination programmes, ensuring long-term public health benefits [42, 45].

Moreover, Integrating interventions across individual, household, community, and policy levels creates a synergistic effect, leading to significant public health impacts. For instance, a 78.93% ITN ownership rate improved to 55.93% consistent usage through community campaigns, while family-centred education programmes reduced under-five malaria incidence by 50% [50, 51]. These outcomes emphasize the importance of designing context-specific and culturally sensitive interventions to foster sustainable behavioural changes and achieve long-term reductions in malaria morbidity and mortality.

Another critical gap in the literature is the lack of research on the long-term sustainability of malaria education interventions. While short-term improvements in knowledge and behaviour have been observed, limited evidence exists regarding whether these changes are maintained over time. Addressing this issue requires future studies to explore strategies that reinforce behavioural change and ensure continuous community engagement beyond initial intervention periods.

Finally, the scalability of family health education programmes remains a challenge, particularly in low-income settings where resource constraints and unequal access to healthcare infrastructure hinder widespread implementation. Strengthening health systems, integrating family health education into broader public health initiatives, and addressing financial barriers to malaria prevention tools such as ITNs and IRS are essential to enhancing programme effectiveness. Additionally, robust monitoring and evaluation mechanisms are needed to assess the long-term impact of these interventions, as many studies lack real-time tracking systems and comprehensive assessment frameworks.

Recommendations

To enhance the impact of malaria elimination programmes, policymakers should focus on equitable resource distribution, strengthening health infrastructure with real-time monitoring systems, and expanding family health education. Financial subsidies for ITNs and IRS should also be prioritized to ensure accessibility for all communities. Sustained community engagement is crucial, utilizing trusted local leaders to conduct culturally sensitive campaigns that build trust and encourage participation.

For long-term sustainability, malaria education must be embedded into routine healthcare services, including maternal and child health check-ups, to ensure continuous awareness. Schools should also incorporate malaria education into their curricula to early preventive behaviours in children. Additionally, behaviour change interventions should be reinforced through digital tools such as SMS reminders, WhatsApp messages, and health apps, as well as media campaigns in local languages. Environmental modifications, such as improved housing structures with mosquito-proofing measures and collaboration with agricultural and water management sectors, can further contribute to long-term malaria elimination programmes.

To ensure the sustainability of malaria education programmes over time, long-term research efforts should be undertaken. Future studies should assess the effectiveness and adaptability of malaria education initiatives in different settings. Research on digital innovations, such as mobile health (mHealth) applications and AI-driven awareness platforms, can help enhance malaria elimination programmes.

Additionally, community engagement models should be explored to determine the most effective approaches for sustaining behaviour change through local leadership and tailored health messaging. Financial sustainability is another key area, requiring studies on cost-effective funding mechanisms like community-based financing and public–private partnerships (Additional files 1, 2, 3, 4).

Lastly, the use of real-time data analytics should be investigated to improve malaria intervention planning, ensuring timely responses and efficient resource allocation. By integrating these approaches, malaria prevention

efforts can achieve lasting impact, reducing disease burden while strengthening community resilience and ensuring the sustainability of malaria education programmes.

Conclusion

In conclusion, this review emphasizes the importance of addressing malaria elimination programmes through a comprehensive approach of the multi-level roles including individuals, families, communities, and policymakers. Effective strategies, such as targeted education campaigns, family health education programmes, and community-led initiatives, have resulted in significant increases in preventive practices such as ITN use and IRS participation. Despite these achievements, challenges persist, such as cultural misconceptions, mistrust of interventions, and resource constraints. Addressing these issues requires equitable resource allocation, improved health infrastructure, and active participation of trusted community leaders. Future efforts should focus on designing long-term, context-specific interventions that foster trust, drive behavioural change, and eventually reduce malaria incidence.

Abbreviations

FDGs	Focus group discussion
IDIs	In-depth interviews
ITN	Insecticides treated net
IRS	Indoor residual spraying
LLIN	Long lasting insecticides netting
MDA	Mass drug administration
MMAT	Mixed methods appraisal tool
ORS	Outdoor residual spraying
PEO	Population exposure outcome
SBCC	Social and behaviour change communication
SSI	Semi-structure interview
WHO	World Health Organization

Supplementary Information

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Additional file 1: Table S1 PRISMA 2020 Abstract Checklist

Additional file 2: Table S2 PRISMA 2020 Checklist

Additional file 3: Table S3 Critical appraisal of articles

Additional file 4: Table S4 Studies identified in literature search

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Author contributions

All authors (MHF, SEWP, MRAM, RS) independently extracted data from articles using a standardized Excel sheet, later reviewed by MHF and MRAM. SEWP and RS provided additional insights and resolved discrepancies. Eligibility screening was conducted independently by MHF, SEWP, and MRAM using predefined criteria. Full-text evaluations confirmed eligibility, with disagreements resolved by RS for consensus. Quality appraisal for all included studies was performed by all authors using the Mixed Methods Appraisal Tool (MMAT).

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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