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# Implementation of malaria control tools in Tanzania: A scoping review using the RE-AIM framework with implications for malaria elimination

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## Abstract

**\*\*Objective:\*\*** This scoping review maps the available evidence on the implementation of key malaria control tools — long-lasting insecticidal nets (LLINs), indoor residual spraying (IRS), artemisinin-based combination therapies (ACTs), and seasonal malaria chemoprevention (SMC) — in Tanzania, analysed through the RE-AIM framework (Reach, Effectiveness, Adoption, Implementation, Maintenance).

**\*\*Methods:\*\*** A scoping review was conducted following the Arksey and O'Malley framework as updated by Levac et al. and Peters et al., and reported in accordance with the PRISMA Extension for Scoping Reviews (PRISMA-ScR). A comprehensive search of PubMed, Scopus, PubMed Central, and Cochrane Library was conducted to identify peer-reviewed studies published between 2000 and 2025 that focused on the implementation of LLINs, IRS, ACTs, and SMC in Tanzania.

**Results:** Following PRISMA-ScR guidelines, 308 records were initially identified, and after screening, six studies met the inclusion criteria. The NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies was used to assess study quality. All six studies demonstrated improvements in malaria-related outcomes, including reduced incidence and increased treatment adherence. The Reach and Effectiveness of LLINs and IRS, particularly when combined, are well-documented, with evidence of up to 45–50% reduction in malaria transmission when the two interventions are deployed together. However, adoption and maintenance are hindered by insecticide resistance, suboptimal net use, and logistical challenges in distribution and monitoring. Mobile health platforms show promise in improving LLIN uptake among pregnant women.

**Conclusions:** The findings suggest that while current malaria control tools in Tanzania are effective, sustained elimination efforts require integrated strategies that address behavioural, operational, and biological barriers. The RE-AIM framework highlights the need for comprehensive evaluation of public health interventions beyond efficacy, especially in resource-limited settings. Future research should prioritise reporting on implementation

fidelity, cost-effectiveness, and long-term sustainability to guide national and global malaria elimination strategies.

**Keywords:** Malaria control; RE-AIM framework; Implementation science; Tanzania; Public health intervention; Malaria elimination; Scoping review

## 1. Introduction

Malaria remains one of the leading causes of morbidity and mortality in sub-Saharan Africa, with Tanzania among the most affected countries. According to the World Health Organization (WHO, 2024), Tanzania accounts for a substantial proportion of global malaria cases, with millions of reported cases annually. The disease disproportionately affects children under five and pregnant women, contributing significantly to healthcare burdens and economic losses (Animut et al., 2025; Sunguya et al., 2021). Despite substantial investments in malaria control, elimination remains elusive due to challenges in implementation, sustainability, and community engagement (Lek et al., 2024). The WHO recommends a combination of interventions for malaria control, including LLINs, IRS, ACTs, and SMC (Mulebeke et al., 2025; WHO, 2021). These tools have demonstrated efficacy in controlled settings; however, their real-world effectiveness is often compromised by contextual and logistical barriers. Understanding the implementation landscape of these tools is essential for scaling up interventions and achieving malaria elimination goals.

The novelty of this scoping review lies in its application of the RE-AIM implementation science framework to simultaneously evaluate all four WHO-recommended malaria control tools — LLINs, IRS, ACTs, and SMC — within the Tanzanian context. Unlike previous reviews that focus on the efficacy of individual interventions, this review maps evidence across all five RE-AIM dimensions (Reach, Effectiveness, Adoption, Implementation, and Maintenance), thereby revealing structural gaps in how implementation outcomes are reported and how programmes can be strengthened for sustained malaria elimination.

The WHO-endorsed malaria control tools each target different aspects of malaria transmission and treatment. LLINs are the most widely distributed intervention and have been shown to reduce malaria morbidity and mortality substantially when used consistently, with evidence from multiple Cochrane reviews confirming significant protective effects (Lengeler, 2004; Pryce et al., 2018). IRS complements LLINs by killing mosquitoes that rest on sprayed surfaces, particularly in high-risk zones. ACTs, which combine artemisinin derivatives with partner drugs, are the first-line treatment for uncomplicated *Plasmodium falciparum* malaria and have significantly improved treatment outcomes [Citation needed]. SMC, primarily used in seasonal transmission areas, involves administering antimalarial drugs to children under five during peak transmission seasons and has demonstrated high efficacy in reducing clinical malaria (Cissé et al., 2016). While these tools are effective in controlled trials, their real-world performance depends on how well they are implemented across diverse settings. In Tanzania, implementation challenges such as inconsistent supply chains, community resistance, and

inadequate health worker training have limited the impact of these interventions. Therefore, evaluating their implementation using a comprehensive framework like RE-AIM is critical to understanding their scalability and sustainability in the context of malaria elimination.

The RE-AIM framework was developed to evaluate the public health impact of interventions by assessing five dimensions: Reach, Effectiveness, Adoption, Implementation, and Maintenance (Glasgow et al., 1999). Reach refers to the proportion of the target population that participates in an intervention. Effectiveness measures the impact of the intervention on health outcomes. Adoption assesses the willingness of individuals or organisations to take up the intervention. Implementation evaluates the consistency and quality of intervention delivery. Maintenance considers the long-term sustainability of the intervention at both individual and organisational levels. The framework has been widely used in implementation science to assess public health programmes, particularly in low- and middle-income countries (Estabrooks et al., 2018; Glasgow et al., 2019). In the context of malaria control in Tanzania, the RE-AIM framework provides a structured approach to understanding how well malaria control tools are being implemented and where gaps exist. By applying the RE-AIM framework, this review aims to provide insights into the implementation landscape of malaria control tools in Tanzania and inform future strategies for malaria elimination.

The research question guiding this scoping review was formulated using the PEO (Population, Exposure, Outcome) framework: Among the general population in Tanzania, including children under five and pregnant women (P), how have WHO-recommended malaria control tools — LLINs, IRS, ACTs, and SMC (E) — been implemented across the five RE-AIM dimensions of Reach, Effectiveness, Adoption, Implementation, and Maintenance (O), and what evidence gaps exist?

This scoping review aims to map the available evidence on the implementation of WHO-recommended malaria control tools — LLINs, IRS, ACTs, and SMC — in Tanzania, analysed through the five dimensions of the RE-AIM framework (Reach, Effectiveness, Adoption, Implementation, and Maintenance), in order to identify implementation evidence gaps and inform strategies for sustainable malaria elimination.

The rationale for this study is grounded in the recognition that while malaria control tools are available and effective in controlled settings, their real-world application is often suboptimal due to implementation challenges. Previous studies have highlighted the need for more comprehensive reporting of implementation outcomes to guide policy and programme planning (Curran et al., 2012). However, few studies have applied the RE-AIM framework to evaluate malaria interventions in Tanzania. By scoping the literature and analysing findings through the RE-AIM lens, this study contributes to the growing body of implementation science in malaria control. It also aligns with global health initiatives that emphasise the importance of context-specific strategies for achieving malaria elimination (WHO, 2024; WHO, 2021). The findings of this review will provide valuable insights for policymakers, programme implementers, and researchers working toward sustainable malaria control in Tanzania and similar settings.

## 2. Methods

### 2.1. Study design

This study is a scoping review conducted following the methodological framework proposed by Arksey and O'Malley (2005) and subsequently updated by Levac et al. (2010) and Peters et al. (2020). The scoping review design was selected in preference to a systematic review because the primary aim is to map the breadth of available evidence on the implementation of malaria control tools in Tanzania across the RE-AIM dimensions, rather than to synthesise effect estimates or answer a narrow clinical question (Munn et al., 2018). This approach is particularly appropriate given the heterogeneity of study designs in the included literature and the need to identify evidence gaps across multiple intervention types (Arksey & O'Malley, 2005). The review is reported in accordance with the PRISMA Extension for Scoping Reviews (PRISMA-ScR; Tricco et al., 2018). The completed PRISMA-ScR checklist is provided as a supplementary file.

### 2.2. Search strategy

A scoping review literature search was conducted using four major electronic databases: PubMed, Scopus, PubMed Central, and Cochrane Library. The search was performed to identify peer-reviewed studies published between 2000 and 2025 that focused on the implementation of malaria control tools in Tanzania. The interventions of interest included LLINs, IRS, ACTs, and SMC. The search terms used included: ("malaria control" OR "malaria elimination") AND ("Tanzania") AND ("LLIN" OR "IRS" OR "ACT" OR "SMC") AND ("RE-AIM"). Boolean operators and truncation symbols were applied to enhance the comprehensiveness of the search. Additionally, reference lists of included studies and relevant reviews were manually scanned for additional eligible studies. The search was conducted in July 2024 and updated in August 2025 to ensure inclusion of the most recent publications. This methodological approach adheres to the PRISMA Extension for Scoping Reviews (PRISMA-ScR) checklist (Tricco et al., 2018), which guides the reporting of scoping reviews and enhances the reproducibility and transparency of the review process. The completed PRISMA-ScR checklist is provided as a supplementary file.

### 2.3. Inclusion and exclusion criteria

Studies were included if they met the following criteria: (1) peer-reviewed articles published between 2000 and 2025; (2) conducted in or focused on Tanzania; (3) evaluated the implementation of any WHO-recommended malaria control tool — LLINs, IRS, ACTs, or SMC; and (4) reported data relevant to at least one RE-AIM dimension, operationalised as follows: Reach (population coverage rates), Effectiveness (changes in malaria incidence, prevalence, parasite positivity rate, morbidity, or mortality), Adoption (uptake by communities, health facilities, or organisations), Implementation (fidelity, quality, or consistency of delivery), and Maintenance (long-term sustainability of coverage or intervention effect). Studies were

excluded if they did not focus on Tanzania, were not published in English, were editorials, conference abstracts, or commentaries, or did not report data relevant to at least one RE-AIM dimension. These criteria were established to ensure relevance to the Tanzanian context and to maintain methodological rigour in the review. The focus on implementation outcomes aligns with the growing emphasis on external validity in public health research (Glasgow et al., 2019).

## 2.4. Study selection

Two independent reviewers screened all titles and abstracts for eligibility based on the predefined inclusion and exclusion criteria. Full-text articles of potentially relevant studies were retrieved and assessed for inclusion. Disagreements between reviewers were resolved through consultation with a third reviewer. A standardised screening form was used to ensure consistency in the selection process. This process was documented using a PRISMA-ScR flowchart to illustrate the selection process and enhance transparency. The dual-screening approach minimises selection bias and ensures that only relevant studies are included in the final synthesis (Liberati et al., 2009).

## 2.5. Data extraction

Data extraction was conducted using a standardised form. The form included the following variables: author/year, country, tool evaluated, study design, sample size, implementation outcomes, and RE-AIM indicators reported. Two reviewers independently extracted data from each included study, and discrepancies were resolved by consensus or by consulting a third reviewer. The extracted data were organised into tables for clarity and ease of analysis. This structured approach to data extraction ensured that all relevant information was captured systematically and consistently across studies, facilitating synthesis using the RE-AIM framework.

## 2.6. Quality assessment

The methodological quality of included studies was assessed using the NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (NIH, 2023). This tool evaluates studies based on several criteria, including sample size justification, control of confounding variables, outcome measurement, and statistical analysis. Each study was rated as "good," "fair," or "poor" based on its adherence to these criteria. Two reviewers independently assessed each study, and discrepancies were resolved through discussion or consultation with a third reviewer. The quality assessment ensured that only studies with adequate methodological rigour were included in the synthesis. The RE-AIM framework guided thematic synthesis across five domains: Reach, Effectiveness, Adoption, Implementation, and Maintenance.

## 2.7. Synthesis approach

A narrative synthesis was conducted using the RE-AIM framework to evaluate the implementation of malaria control tools across the five dimensions: Reach, Effectiveness, Adoption, Implementation, and Maintenance. The synthesis followed the guidance provided for narrative synthesis in scoping reviews (Peters et al., 2020). Findings were organised by intervention type and RE-AIM dimension to facilitate comparison and interpretation. The narrative synthesis approach was chosen due to the heterogeneity of study designs and outcome measures, which precluded a meta-analysis. This method allows for a comprehensive and context-sensitive interpretation of findings, particularly in implementation science where qualitative and contextual factors play a critical role (Curran et al., 2012). The synthesis also included a discussion of gaps in reporting across the RE-AIM dimensions and recommendations for future research and policy.

## 3. Results

### 3.1. Study selection

The initial search yielded 308 records across the four databases: PubMed (156), Scopus (129), PubMed Central (7), and Cochrane Library (17). After deduplication, 222 unique records remained. After title and abstract screening, 24 underwent full-text review. Eighteen were excluded for reasons including lack of implementation outcomes (n=5), not focused on Tanzania (n=6), qualitative-only design (n=4), or irrelevant intervention (n=3). Six studies met all criteria and were included in the final synthesis. The PRISMA-ScR flowchart (Fig. 1) illustrates the selection process and demonstrates the systematic approach taken to ensure that only relevant and high-quality studies were included in the review.

**Fig. 1.** PRISMA-ScR Flowchart diagram of search results

### 3.2. Study characteristics

The six included studies encompass a range of designs and populations, all conducted in Tanzania. Interventions evaluated include LLINs (n=3), IRS (n=2), ACTs (n=2), SMC (n=1), and combinations thereof. Most studies employed quantitative or mixed-methods approaches, with only one purely observational design (Table 1).

**Table 1.** Summary of study characteristics.

Author, Year	Country	Tool Evaluated	Study Design	Key Outcomes
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| Protopopoff et al., 2015 [VERIFY] | Tanzania | LLINs + IRS | Cluster RCT | Combination reduced vector density and malaria transmission more than LLINs alone |

| Khatib et al., 2019 [VERIFY] | Tanzania | ACTs | Quasi-experimental | Improved adherence with community health worker support |

| Mwaiswelo et al., 2024 [VERIFY] | Tanzania | SMC | Cluster RCT | Significant reduction in under-5 malaria cases in targeted regions |

| Kaufman et al., 2012 [VERIFY] | Tanzania | IRS | Qualitative (FGDs & IDIs) | Identified key social and cultural barriers to IRS acceptance |

| Vey et al., 2024 [VERIFY] | Tanzania | LLINs (mHealth) | RCT | Mobile voucher system increased LLIN uptake among pregnant women |

| Vey et al., 2025 [VERIFY] | Tanzania | LLINs (mHealth) | Cluster RCT | Targeted behaviour change communication improved net use and retention |

### 3.3. RE-AIM reporting

#### #### 3.3.1. Reach

The reach of malaria control tools in Tanzania varies significantly by intervention and delivery strategy. School-based and antenatal care (ANC) platforms have enhanced access to LLINs among children and pregnant women. The Hati Salama (HASA) trial demonstrated that a mobile health-based voucher system significantly improved LLIN distribution to pregnant women in rural areas, increasing uptake from baseline [VERIFY: Vey et al., 2024]. Similarly, continuous distribution through schools maintained high coverage, with over 80% of schoolchildren receiving nets in southern Tanzania [Citation needed]. SMC reached over 30% of eligible children under five in pilot areas, though coverage gaps persist in hard-to-reach communities [VERIFY: Mwaiswelo et al., 2024].

#### #### 3.3.2. Effectiveness

LLINs and IRS remain highly effective in reducing malaria transmission, particularly when used in combination. The Reach and Effectiveness of LLINs and IRS, particularly when combined, are well-documented, with evidence of up to 45–50% reduction in malaria transmission when the two interventions are deployed together (Mulebeke et al., 2025; Zhou et al., 2022). A randomised controlled trial in northern Tanzania found that combining IRS with LLINs led to a 45% greater reduction in vector population density compared to LLINs alone [VERIFY: Protopopoff et al., 2015]. ACTs have shown high efficacy, with over 95% cure rates in clinical trials, though effectiveness is threatened by emerging resistance and incomplete adherence [VERIFY: Khatib et al.]. SMC was associated with a 30–40% reduction in clinical malaria episodes among children under five in seasonal transmission zones (Mwaiswelo et al., 2021).

#### #### 3.3.3. Adoption

Community adoption of interventions is influenced by knowledge, trust, and perceived risk. IRS faces resistance in some communities due to misconceptions about chemical safety and

cultural beliefs (Kaufman et al., 2012). Qualitative findings revealed that while many households accepted IRS, others refused due to fears of poisoning, damage to walls, or spiritual concerns (Kaufman et al., 2012). In contrast, LLINs are widely accepted, with over 90% willingness to use them when properly distributed and accompanied by education. Mobile health interventions that deliver targeted messaging have further improved adoption by addressing individual barriers [VERIFY: Vey et al., 2025].

#### #### 3.3.4. Implementation

Implementation fidelity varies across programmes. LLIN distribution through schools and ANC clinics has been logistically supported by strong supply chains and trained personnel [VERIFY: Protopopoff et al.]. However, IRS programmes face challenges in spray operator training, insecticide availability, and community mobilisation. The use of insecticide quantification kits revealed inconsistent spraying quality across regions, with rapid decay of bendiocarb on porous wall surfaces (Thawer et al., 2015). Digital tools, including mobile vouchers and SMS reminders, have improved implementation efficiency and monitoring accuracy [VERIFY: Vey et al., 2025, 2024].

#### #### 3.3.5. Maintenance

Long-term maintenance of malaria control tools is threatened by insecticide resistance and net durability. Multiple studies report high levels of pyrethroid resistance in *Anopheles gambiae* and *An. funestus*, reducing the efficacy of standard LLINs (Tungu et al., 2023). Dual-active ingredient nets (e.g., PBO-LLINs) show promise but are not yet widely deployed. Physical net integrity declines after 2–3 years, especially in high-temperature environments, reducing protective effect. Behaviour change communication and continuous distribution strategies are critical for sustaining high coverage and use over time (Nambatya et al., 2025). [VERIFY: Original manuscript cited "Kabula et al., 2024" which is not in the verified reference library — replaced with Tungu et al., 2023 and Nambatya et al., 2025 from verified library. Author to confirm accuracy.]

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## 4. Discussion

The findings of this scoping review demonstrate that while Tanzania's malaria control tools — LLINs, IRS, ACTs, and SMC — demonstrate strong Reach and Effectiveness profiles, the Adoption, Implementation, and Maintenance dimensions of the RE-AIM framework are consistently underreported and underperforming. This pattern is consistent with observations from implementation science literature that public health programmes in low-resource settings frequently prioritise coverage metrics over implementation fidelity (Estabrooks et al., 2018; Glasgow et al., 2019).

The combination of LLINs and IRS has shown the strongest evidence base in terms of Reach and Effectiveness, with synergistic reductions in vector density reported in Tanzania (Mulebeke et al., 2025; Zhou et al., 2022). However, the Maintenance of IRS programmes is particularly vulnerable to insecticide resistance (Tungu et al., 2023), logistical constraints (Thawer et al., 2015), and community acceptance barriers (Kaufman et al., 2012). These findings align with global evidence that IRS programmes are difficult to sustain without consistent funding and strong community engagement (WHO, 2024).

SMC has demonstrated meaningful Effectiveness in reducing clinical malaria episodes among children under five (Cissé et al., 2016; Mwaiswelo et al., 2021), but its Implementation is constrained by seasonal timing, supply chain dependencies, and coverage gaps in hard-to-reach populations. The application of the RE-AIM framework reveals that SMC's Adoption and Maintenance dimensions are the least well-documented in the Tanzanian literature, representing a critical evidence gap.

The application of the RE-AIM framework to this evidence base is consistent with its growing use in global health implementation research (Glasgow et al., 2019; Jolles et al., 2024; Reisinger et al., 2025). The framework's utility lies in its capacity to reveal not only whether an intervention works, but how well it is delivered, adopted, and sustained in real-world settings — a distinction that is critically important for malaria elimination planning (Curran et al., 2012; Zhang et al., 2025).

A notable limitation of this review is its broad scope, which encompasses four distinct interventions. While this breadth is appropriate for a scoping review intended to map the evidence landscape and identify cross-cutting implementation gaps, it limits the depth of analysis for individual tools. Future scoping or systematic reviews focusing on a single intervention — such as LLINs or SMC — would enable more granular analysis of implementation fidelity, equity dimensions, and dose-response relationships.

Additional limitations include the small number of included studies (n=6) and the restriction to English-language publications, which may introduce language bias. The heterogeneity of study designs precluded meta-analytic synthesis. Furthermore, several included studies did not explicitly report all five RE-AIM dimensions, which limited the completeness of the framework mapping.

Future research should prioritise prospective studies that explicitly collect and report data across all five RE-AIM dimensions. Implementation science frameworks such as RE-AIM, when integrated into study design from the outset rather than applied retrospectively, offer the greatest potential for generating actionable evidence for programme scale-up (Proctor et al., 2023; Curran et al., 2012).

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## 5. Conclusions

This scoping review mapped the available evidence on the implementation of WHO-recommended malaria control tools in Tanzania using the RE-AIM framework. The findings confirm that LLINs, IRS, ACTs, and SMC demonstrate strong Reach and Effectiveness profiles, but face persistent challenges in Adoption, Implementation fidelity, and Maintenance. The RE-AIM framework identifies critical evidence gaps — particularly in the Adoption and Maintenance dimensions — that must be addressed to support sustainable malaria elimination in Tanzania. Integrated strategies that address behavioural, operational, and biological barriers simultaneously are needed. Future research and programme evaluations should systematically report all five RE-AIM dimensions to facilitate cross-programme learning and scale-up of effective interventions.

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