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Operationalizing multisectoral action for malaria control in a peri-urban setting in Burkina Faso: a community-driven larval source management intervention evaluated in a quasi- experimental pre–post study

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Title: Operationalizing multisectoral action for malaria control in a peri-urban setting in Burkina Faso: a community-driven larval source management intervention evaluated in a quasi-experimental pre–post study

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Abstract

Background: Malaria transmission is shaped by a complex interplay of determinants within and beyond the health sector, making it unlikely to be addressed by health systems alone. The WHO's Global Technical Strategy for Malaria 2016–2030 advocates for a multisectoral approach (MSA). However, MSA operationalization remains limited in sub-Saharan Africa. This study evaluates a

community-driven larval source management (LSM) intervention implemented through a multisectoral collaboration in a high malaria burden setting of Burkina Faso.

Methods: An LSM campaign (21 August to 5 September 2023) was evaluated in Manga using a pre–post quasi-experimental design with a non-randomized control area. The intervention was led by a newly established Multisectoral Coordination Committee for Malaria Elimination (CMEP), formed following stakeholder mapping. A total of 307 community volunteers carried out physical destruction of mosquito breeding sites over a 16-day period, followed by a household survey. Entomological indicators (mosquito aquatic habitats positivity, indoor resting density, and human biting rate) were measured at baseline (V0), mid-intervention (V1), and one-month post-intervention (V2). Data were analyzed using mixed-effects models and difference-in-differences (DiD) approaches.

Results: Stakeholder mapping identified 12 sectors, enabling the establishment of the CMEP with formally endorsed terms of reference. The community survey showed high engagement, with 96.6% of surveyed respondents reporting having destroyed mosquito aquatic habitats and 88.3% maintaining the practice post-intervention. By endline, mosquito aquatic habitats positivity decreased to 2.2% in the intervention area, compared to 25.2% in the control area, corresponding to 95% lower odds of positivity (OR = 0.05; 95% CI: 0.01–0.19). Total adult mosquito densities declined in both areas, likely reflecting seasonal effects. A temporary increase in *Anopheles* density was observed at mid-intervention in the intervention area, followed by a significant 70% reduction from V1 to V2. The overall DiD effect was not statistically significant, likely due to this transient pattern and limited statistical power.

Conclusions: A community-driven MSA intervention, implemented through the CMEP, was associated with substantial short-term reductions in mosquito aquatic habitats. The CMEP offers an

adaptable model for multisectoral collaboration in malaria control. However, sustained impact will require longer-term implementation and dedicated financing mechanisms.

Keywords: Peri-urban malaria, Multisectoral approach, Larval source management, Vector control, Community engagement

Background

Burkina Faso remains one of the eleven highest malaria-burden countries in the world, with an estimated 8.1 million cases and approximately 15 000 deaths in 2023 [1], despite sustained coverage of core interventions. At the global level, the scale-up of insecticide-treated nets (ITNs), indoor residual spraying (IRS), and improved access to diagnosis and treatment led to substantial reductions in malaria mortality between 2000 and 2015. However, progress has stalled over the past decade, driven by declining effectiveness of frontline tools due to insecticide and drug resistance, alongside persistent health system constraints and rapid urbanization [2-4].

Malaria transmission is sustained by a complex system of ecological, environmental, and social determinants that often lie outside the direct influence of the health sector [5]. Factors such as rapid urbanization, poor sanitation, and inadequate waste management create abundant mosquito breeding sites in both urban and rural areas, perpetuating disease transmission [6, 7]. Addressing these root causes requires novel and integrated strategies that complement existing vector control methods [8]. Larval source management (LSM) encompasses a variety of techniques, including habitat modification, habitat manipulation, and larviciding, and targets immature mosquitoes before they emerge as adults. The WHO has recommended the implementation of LSM as a supplementary vector control measure in settings where breeding sites are few, fixed, and findable [9]. Peri-urban areas present particular opportunities for LSM. The combination of poor drainage and informal construction

creates conditions conducive to the establishment of identifiable breeding sites, while population density facilitates community mobilization. However, these settings have received comparatively less research attention than rural endemic zones [10]. The WHO Global Technical Strategy for Malaria 2016–2030 calls for a multisectoral approach (MSA) to address broader determinants of transmission [11]. However, case studies or success stories on the implementation of MSA are limited in sub-Saharan Africa. Ethiopia recorded a 73% decline in malaria-related deaths between 1990 and 2015 in the context of broad development progress including poverty reduction, education, and safe water access [12]. In Zambia, an Integrated Vector Management (IVM) framework combining long-lasting insecticidal nets (LLINs), IRS, and supplementary larval source management has been adopted as the national vector control strategy, contributing to a reduction in malaria-related morbidity and mortality [13, 14].

To facilitate the implementation of MSA, the Special Programme for Research and Training in Tropical Diseases (TDR) released a conceptual framework in 2020 [15] that outlines the essential elements of successful multisectoral collaborations for preventing and controlling vector-borne diseases (VBDs). Since then, TDR has been supporting countries in implementing MSA. This manuscript reports on a case study where the objectives were to (i) identify relevant stakeholders from non-health sectors that could support malaria control activities, (ii) determine a joint activity to implement through a multisectoral collaboration, and (iii) assess the impacts and benefits of implementing the joint activity for the health and non-health sectors. The joint activity was community-driven *Anopheles* larval source management (LSM).

Methods

Study design

A pre-post quasi-experimental design with a non-randomized control area was implemented to assess the entomological effect, embedded within a mixed-methods implementation research framework [16,

17]. The study was conducted in two peri-urban zones of Manga selected based on comparable ecological, demographic, and socio-environmental characteristics identified during a preliminary field assessment. One zone was assigned as the intervention area and the other as the control; random allocation was not feasible due to operational constraints.

The study followed a sequential implementation process comprising four main phases. First, a stakeholder mapping and assessment of sectoral capacities was conducted (August-September 2022) to identify relevant stakeholders and existing institutional roles. Second, a Multisectoral Coordination Committee for Malaria Elimination (CMEP) was established to determine and discuss the implementation of a joint activity. Third, a community-led larval source management (LSM) campaign was implemented in the intervention area (August-September 2023), consisting mainly of the physical destruction of mosquito aquatic habitats, complemented by drainage rehabilitation and waste removal. Finally, entomological surveys were conducted at baseline, mid-intervention and endline in both intervention and control areas to assess changes in mosquito aquatic habitats positivity and adult mosquito density. The household surveys were conducted at the end of the intervention period.

The mixed-methods approach combined quantitative entomological and household survey data with qualitative information from stakeholder engagement processes. This design enabled assessment not only of the intervention's effectiveness but also of the institutional and operational mechanisms influencing its implementation.

Study setting

The study was conducted in Manga (11.6636° N, 1.0731° W), a peri-urban town, capital of Zoundwéogo province, Burkina Faso. The population was estimated at approximately 44 000 inhabitants in 2019 [18]. The area is characterized by limited sanitation infrastructure, with only 4.5% of households having access to septic systems and over 80% discharging wastewater into open spaces.

During the rainy season, poor drainage and accumulated waste create numerous stagnant water bodies that serve as potential mosquito breeding sites.

The city of Manga is administratively divided into five sectors. Sectors 3 and 4 were selected as the intervention area, while the contiguous sectors 1, 2, and 5 served as the control area (Figure 1) and received no intervention during the study period. Site selection was based on comparable ecological and socio-environmental characteristics, including housing density, drainage infrastructure, and baseline mosquito aquatic habitats density, as confirmed by the baseline entomological survey (V0) conducted in July 2023 (57 vs. 52 active breeding sites; larval positivity 26.3% vs. 28.8%, p = 0.80).

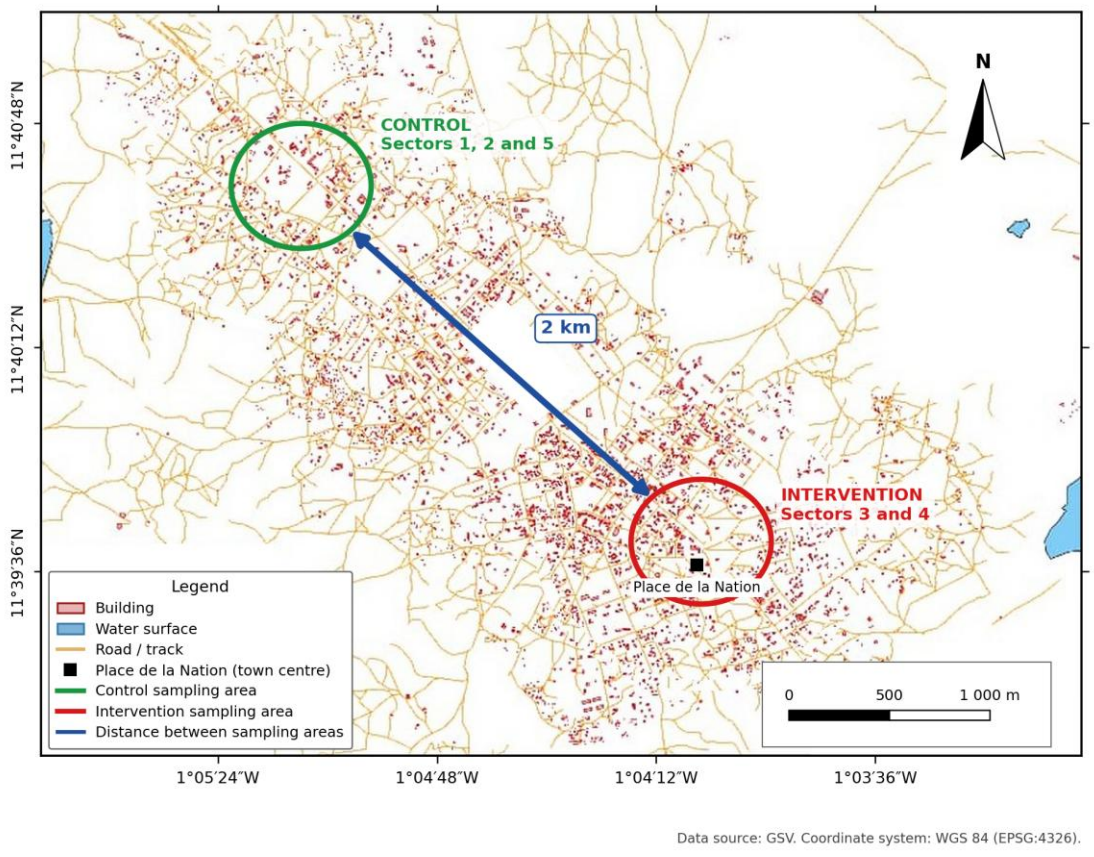


Figure 1. Map of Manga showing the control and intervention sampling areas. Entomological sampling areas in the control zone (Sectors 1, 2 and 5; green) and the intervention zone (Sectors 3 and 4; red). Sampling areas were located 2 km apart (arrow). Coordinate system: WGS 84 (EPSG:4326).

Randomization was not feasible as only these two zones met the comparability criteria while remaining operationally manageable for a single-team intervention. Entomological sampling points were located at least 2 km apart between zones to limit cross-zone mosquito dispersal, consistent with the typical flight range of *An. gambiae* s.l. [19].

Phase 1: Stakeholder mapping and qualitative assessment

Between August and September 2022, we conducted semi-structured individual interviews with 25 key informants (KIs) across 12 institutional sectors, comprising the health sector and eleven non-health sectors, to identify which actors held practical leverage over the conditions sustaining malaria transmission. Sectors were selected jointly with SP/Palu, based on whether their mandate covered infrastructure, land use, or public services with measurable effects on standing water or community mosquito exposure, and included territorial collectivities, education, transport, communication, urban planning, water and sanitation, economy and finance, agriculture, environment, security, and technical and financial partners.

Four socio-anthropologists holding a bachelor's degree (licence) in sociology, trained over two days on the semi-structured guide, conducted interviews under the supervision of the qualitative lead. Key informants were approached by telephone, and each interview lasted approximately one hour. Thematic areas covered: sectoral knowledge of malaria transmission; perceived roles in vector control; feasibility of intersectoral collaboration; and conditions for joint action. Saturation was reached after approximately ten interviews. The remaining interviews were conducted to ensure that each of the 12 selected sectors was represented.

Phase 2: Setting up a multisectoral coordination committee (CMEP)

Building directly on the stakeholder mapping findings, the CMEP was formally established in late 2022 under ministerial endorsement from the Ministry of Health. Its Terms of Reference were

developed with reference to the WHO handbook for integrated vector management [20] and validated through a participatory consultation in which each prospective member sector reviewed and endorsed its assigned role. The governance structure was designed to avoid dominance by the health sector, with a non-health sector chair, two vice-chairs from the water and sanitation and urban planning sectors, and SP/Palu as Secretary-General. Members were drawn from nine institutional categories spanning health, territorial collectivities, urban planning, water and sanitation, agriculture, environment, education, economy and finance, and technical as well as financial partners. Each member was assigned a concrete operational role aligned with their existing mandate rather than a generic advisory function.

Phase 3: Implementation of the joint Larval Source Management (LSM) Intervention

At a planning workshop held in March 2023, the CMEP selected the physical destruction of mosquito aquatic habitats as the joint intervention. This decision was made primarily because the intervention required no specialized inputs or procurement, could be executed by community volunteers with minimal training, and provided each participating sector with a concrete role that fell within its operational mandate. Manga was confirmed as the pilot site: its malaria incidence exceeded the national average by 15% [21]. Preliminary field assessment had already identified multiple active *Anopheles* breeding sites and the mayor had personally committed to mobilizing municipal services for the campaign.

Field implementation ran from 21 August to 5 September 2023. During the baseline survey (V0, July 2023), a team of 10 entomology technicians completed a comprehensive habitat census across both zones, assigning each site a unique ID and recording type, water surface area, and permanence. This baseline mapping served simultaneously as the operational targeting list for the destruction campaign.

Mobilization was organized through traditional chiefs, youth association leaders, and local radio, channels selected deliberately given the low adult literacy rate in the province. Field teams conducted

door-to-door visits to identify and destroy domestic breeding sites, tipping over water containers, filling puddles, and cleaning blocked gutters, while municipal sanitation crews worked in parallel on drainage rehabilitation along the main roads. A total of 307 volunteers from Sectors 3 and 4 participated across the 16-day campaign, each assigned to a specific neighborhood under the supervision of a trained sector coordinator.

Phase 4: Post-intervention entomological and community evaluation

Entomological assessment

A series of entomological surveys was conducted at three distinct time points: the baseline (V0, July 2023), during the intervention period (V1, early September 2023), and one month following the conclusion of the intervention (V2, October 2023). These surveys were conducted in both the intervention and control areas. The three-round design enabled us to distinguish the pre-intervention baseline from the mid and post-campaign conditions, as well as helping to distinguish intervention-related changes from seasonal variation alone [16]. The primary entomological outcomes were: (i) mosquito aquatic habitats positivity rate (proportion of surveyed sites positive for *Anopheles* larvae); (ii) indoor resting density expressed as mean number of *Anopheles* per house per PSC collection; and (iii) human biting rate expressed as mean number of *Anopheles* per person per night from HLC.

Larval survey

Before the intervention, a team of 10 field entomology technicians conducted a comprehensive larval breeding site survey across the control and the intervention area. Potential breeding sites were identified and mapped using a tablet-based data capture interface, following WHO larval surveillance guidelines [9]. Each habitat received a unique identifier, with details on habitat type, water surface area, permanence, and surrounding vegetation recorded. This mapping provided baseline status and facilitated the monitoring of the reduction of mosquito aquatic habitats.

200 Larval samples were collected using dipping techniques [9]. The collected larvae were transported to
201 the laboratory, where they were sorted into *Anopheles* and non-*Anopheles* categories based on
202 established morphological keys [22]. Larval stages were annotated as early (L1-L2) or late (L3-L4).
203 From these data we calculated larval density per habitat and habitat positivity rate, the proportion of
204 surveyed sites positive for *Anopheles* larvae, at each round.

205 A formal a priori sample size calculation was not performed for mosquito aquatic habitats positivity:
206 the sample corresponds to the exhaustive census of habitats identified in both zones rather than to a
207 pre-specified target. Precision is therefore reported through confidence intervals around the model
208 estimates rather than through post-hoc power estimates.

209 *Adult mosquito survey*

210 Adult mosquito populations were monitored by two complementary methods chosen to capture both
211 indoor resting density and human exposure:

212 Pyrethrum Spray Catches (PSC) served as an index for measuring the indoor resting density of adult
213 mosquitoes, particularly *Anopheles* spp. [23]. Assessments were conducted at each survey round in 60
214 randomly selected households (30 per zone at V1 and V2; 32 control and 28 intervention households
215 at baseline), consistent with WHO operational guidance for PSC-based vector surveillance. While this
216 sample size is commonly used in field studies, the study was not formally powered to detect specific
217 effect sizes under the observed variability and non-linear response patterns.

218 Households were randomly drawn from sector census lists at each round to limit selection bias,
219 unavailable households being replaced by the next household on the list. A non-residual insecticide
220 spray (d-phenothrin + pyrethrum) was applied to the inner walls, and any knocked-down mosquitoes
221 were collected on white sheets. Household characteristics including wall material, eave type, and
222 presence of domestic animals were recorded at each visit [24] but were not included as covariates in
223 the models.

Human Landing Catches (HLC) were conducted at each survey round over two consecutive nights, with two households per zone sampled each night (four house-nights per zone per round). While this sample size is limited, and precludes definitive causal inference from HLC data alone, it is consistent with operational constraints and was designed to provide directional evidence of intervention effects on human biting exposure; HLC data are therefore reported descriptively. Collectors worked in pairs, alternating between indoor and outdoor positions every two hours from 19:00 to 06:00, aspirating host-seeking mosquitoes upon landing on exposed lower limbs before biting. All collectors provided written informed consent and received free malaria treatment in accordance with national guidelines whenever they were diagnosed with malaria during the study.

Laboratory procedures

Specimens were categorized by sex and species using morphological characteristics [22]. Female mosquitoes were further classified by gonotrophic stage (unfed, fed, semi-gravid, gravid) through visual examination of the abdomen using a dissecting microscope. All specimens were preserved individually in labeled Eppendorf tubes containing silica gel. Molecular speciation by PCR was not performed due to logistical and funding constraints. Specimens of the *An. gambiae* complex were therefore reported as *An. gambiae* s.l., which in this region of Burkina Faso comprises primarily *An. gambiae* s.s. and *An. coluzzii* [25]. A small number of *An. funestus* group specimens (n = 25) were also identified morphologically.

Evaluation of community engagement

Post-intervention household survey

A structured post-intervention survey (N = 206) was conducted in October 2023 within the intervention zone to assess community awareness, participation, and sanitation practices following the mosquito aquatic habitats destruction campaign. Households were systematically selected from sector census lists, with the head of household or their spouse as the primary respondent. The questionnaire covered:

awareness of the campaign and its objectives; sources of information received; personal participation in habitat cleaning activities; and frequency of repeated domestic action. It was pre-tested before deployment and administered face-to-face in French or Mooré (local language), depending on respondents' preference [17].

Operational monitoring

Operational performance was also tracked against five pre-defined indicators aligned with WHO vector control guidance [26]: number of mosquito aquatic habitats destroyed, number of households reached, number of sectors actively participating, number of individuals trained, and community adherence rate. Data were captured through daily field supervisor logs, training attendance registers, and a final capitalization workshop held in October 2023 at which sector representatives reported on their contributions and the barriers encountered during implementation.

Data analysis

Sociodemographic and behavioral data from the household survey were summarized using descriptive statistics, frequencies and proportions for categorical variables, means and standard deviations for continuous variables [27].

Qualitative interview data were analyzed thematically following the approach of Braun and Clarke [28]. All interviews were audio-recorded, transcribed verbatim, and coded in NVivo Pro 12 using a mixed deductive-inductive approach [29]: primary codes derived from the interview guide structure and secondary codes emerging iteratively from the transcripts. Themes and sub-themes were refined until saturation [30].

For entomological outcomes, mosquito aquatic habitats positivity was modeled using a binomial generalized linear mixed model (GLMM) with fixed effects for Zone (Intervention vs. Control), Round (V0–V2) and their interaction, plus random intercepts for site (each habitat uniquely identified within its zone) to account for repeated measurements [31, 32]. For the GLMM analysis, the analytical dataset

comprised all breeding-site visits (n=587 observations across 241 unique sites; see Additional file 1, Table S1), including sites that had been destroyed but re-inspected to confirm larval absence. This differs from the "active sites" counts reported in the Results (larval breeding-site dynamics), which reflect sites with standing water at the time of visit. Estimated marginal means were derived using the emmeans package [33]. A sensitivity analysis restricted the model to habitats holding water at inspection and adjusted for breeding-site type; water presence itself could not be modeled because no dry habitat was positive. Breeding-site type was coded as recorded at the first inspection of each habitat. Because destroyed habitats are retained as negative observations in the main model, this sensitivity analysis also indicates how much of the main effect depends on their inclusion.

For adult mosquito density (PSC), a difference-in-differences (DiD) framework was used to account for pre-existing baseline imbalance in *An. gambiae* s.l. indoor resting density between zones. The DiD estimator, the Zone × Round interaction in a negative-binomial GLM, estimates the intervention effect from differential change over time, absorbing both baseline differences and shared seasonal trends [34]. A GLM rather than GLMM was used because PSC households were independently sampled at each round. The parallel trends assumption is supported by comparable baseline larval positivity and shared ecological conditions, though it cannot be formally tested with a single pre-intervention time point. Complementary within-zone analyses (V1 to V2) characterized post-disturbance trajectories separately. HLC biting rates were expressed per person per night, as the mean of the indoor and outdoor catches of each house-night (four house-nights per zone per round), and are reported descriptively only. Residual diagnostics for the negative-binomial models used simulated residuals (DHARMa [35]); for the binary-outcome GLMM, model fit was checked by comparing model-predicted with observed positivity (Figure 2). Significance was set at $p < 0.05$. All analyses were performed in R version 4.3.3 using the lme4 (v1.1-35.1), MASS, emmeans (v1.10.0) and DHARMa packages. One structural feature of the design constrains all inference reported below: the intervention was allocated at the level of the study zone, so the study comprises two clusters only, whereas the models treat

habitats and households as the units of analysis. Between-cluster variance cannot be estimated from two clusters, and the standard errors and p-values reported here do not incorporate it. They should therefore be regarded as anti-conservative, and all estimates interpreted as associations rather than as causal effects.

Use of artificial intelligence tools

A large language model (Claude, Anthropic) was used to assist with English-language editing and to improve the readability of the manuscript. It was not used to design the study, collect or analyze the data, or interpret the findings. The authors reviewed and edited all suggested text and take full responsibility for the content of the manuscript.

Results

Stakeholder mapping and qualitative assessment

Participant profile and sectoral coverage

Twenty-five key informants were interviewed across 12 institutional sectors. The sample was predominantly men (23/25, 92%) and highly experienced: 84% of participants (21/25) had over 10 years of professional experience in their sector. Just over half (14/25, 56%) came from the health sector, including central and regional directors. The remaining 44% (11/25) each represented one non-health sector: territorial collectivities, education, transport, communication, urban planning, water and sanitation, economy and finance, agriculture, environment, security, and technical and financial partners.

Sectoral knowledge and perceived roles

Health sector informants were the best informed about malaria control strategies. Non-health sector informants had more limited awareness of transmission dynamics, though most recognized that vector control extended beyond the health sector's mandate. Several spontaneously identified drainage, waste

management, and urban planning as domains in which their sector held direct operational responsibility for mosquito aquatic habitats conditions.

Perceived contributions of non-health sectors

Informants identified specific contributions that each sector could make within a joint framework. Given their existing mandate over urban sanitation and drainage, territorial collectivities were seen as natural leaders for larval habitat management. The agricultural and environmental sectors were identified as key actors in pesticide management and land-use planning. Research institutions (CNRST, CNRFP, Centre Muraz) were recognized for their capacity to generate operational evidence. Technical and financial partners were positioned as resource mobilizers rather than implementers.

Conditions and barriers to intersectoral collaboration

All 25 informants expressed willingness to participate in joint malaria action, but identified four structural barriers consistently across sectors: absence of any formal coordination mechanism linking health to non-health sectors; no dedicated budget lines for malaria activities in non-health ministries; obsolete or insufficient field logistics (i.e., rolling stock and field equipment such as supervision vehicles, motorcycles for field visits, and other materials needed to deploy staff and supplies to operational sites) across most entities; and limited technical capacity among non-health staff to engage in vector control without prior training. Informants drew repeated comparisons with the HIV response, where presidential-level commitment and a dedicated national secretariat had enabled cross-sectoral mobilization that malaria control had never achieved.

Recommendations for the multisectoral committee

Informants converged on three conditions for an effective CMEP: strong political leadership anchored at the Ministry of Health, a participatory design assigning each sector a concrete and sector-specific operational role, and domestic resource mobilization as the primary funding strategy. Several

recommended designating technically capable mid-level focal points rather than senior officials, whose agenda constraints were seen as a recurrent obstacle to regular participation.

Establishment of a Multisectoral Coordination Committee (CMEP)

Establishment and governance structure

Building directly on the sectoral mapping findings, the CMEP was formally established in late 2022 and its Terms of Reference endorsed by the Ministry of Health in early 2023. The committee brought together representatives from nine institutional categories: Health (SP/Palu, DPES), Territorial Collectivities (AMBF), Urban Planning (MUAFH), Water and Sanitation (DREA), Agriculture, Environment, Education (MENAPLN), Economy and Finance (DPP), and Technical and Financial Partners (UNICEF, Global Fund, NGO Terre des Hommes). The governance structure deliberately avoided health-sector dominance, with the following composition: (i) chair: a non-health sector; (ii) two vice-chairs: the water and sanitation and the urban planning sectors; (iii) Secretary-General: SP/Palu; and (iv) members: representatives of the remaining member categories (health, territorial collectivities, education, agriculture, environment, economy and finance, and technical and financial partners). The CMEP served as the coordinating body for planning, oversight, and sustainability of the intervention.

Sectoral roles and terms of reference

Each member sector was assigned a concrete operational role aligned with its existing institutional mandate rather than a generic advisory function. Territorial collectivities (AMBF) took responsibility for drainage channel maintenance and community sensitization, activities explicitly within their urban sanitation mandate. The urban planning directorate (MUAFH) committed to road infrastructure works, stormwater drainage design, and urban waste management. Water and sanitation (DREA) covered household wastewater management and drinking water provision. The education ministry

(MENAPLN) engaged through school latrine and borehole construction and hygiene promotion within school environments. Economy and Finance (DPP) was positioned as a resource mobilization and financial advocacy actor. Technical and financial partners (UNICEF, Global Fund, NGO Terre des Hommes) provided technical support for planning and data analysis rather than direct field implementation.

Participatory validation process

The Terms of Reference were developed through a participatory consultation process in which each sector reviewed and validated its assigned role before formal endorsement. This process addressed a key barrier identified during stakeholder mapping: several non-health sector informants had expressed concern about being assigned activities disconnected from their core mandate. By anchoring each sector's contribution to its existing operational responsibilities, the CMEP design aimed to reduce the coordination costs of joint action and increase the likelihood of sustained participation beyond the pilot intervention.

Structural challenges at establishment

Despite broad willingness to participate, three structural constraints were documented at the time of CMEP establishment. Non-health sectors had no dedicated budget lines for malaria-related activities, making their financial contribution dependent on reallocation from existing sector budgets or external mobilization. Field logistics (vehicles and supervision equipment) were reported as obsolete or insufficient across most participating entities. Several non-health sector focal points required capacity building on malaria transmission and vector control before they could engage meaningfully in joint planning. These constraints were acknowledged in the CMEP's inaugural working session and incorporated into the committee's first operational plan.

Community post intervention evaluation

Participant profile

A total of 206 residents were surveyed in the intervention zone (Table 1). The sample was slightly majority female (107/206, 51.9%) versus male (99/206, 48.1%). Respondents ranged in age from 17 to 75 years, with a mean age of 36.9 years (SD = 13.2).

Table 1. Sociodemographic characteristics of survey respondents

Characteristic	**n**	**%**
Total enrolled	**206**	**100.0**
Sex		
Male	99	48.1
Female	107	51.9
Total	**206**	**100.0**
Age (years)		
Mean (SD)	36.9 (13.2)	—
Range (min – max)	17 – 75	—

Awareness of the mosquito aquatic habitats destruction campaign

Two-thirds of respondents (136/206, 66.0%) reported awareness of the mosquito aquatic habitats destruction activities, with comparable rates between men (64/99, 64.6%) and women (72/107, 67.3%) (Table 2). Among those who were aware, the dominant information channel was word of mouth, 112 of 136 (82.4%) learned about the campaign through person-to-person communication. Radio reached only 4 respondents (2.9%) and a single respondent reported learning through a traditional chief, while the channel was other or unspecified for 19 respondents (14.0%). This pattern is consistent with the

intervention design, which deliberately prioritized interpersonal channels over broadcast media given the province's documented low adult literacy.

Table 2. Awareness of the mosquito aquatic habitats destruction campaign and information channels

	Male	**Female**	**Total (n)**	**Total (%)**
Awareness of mosquito aquatic habitats destruction activities				
Aware	64 (64.6%)	72 (67.3%)	**136**	**66.0**
Not aware	35 (35.4%)	35 (32.7%)	**70**	**34.0**
Total	**99**	**107**	**206**	**100.0**
Information channel (among aware respondents, n = 136)				
Word of mouth	—	—	112	82.4
Radio	—	—	4	2.9
Traditional chief	—	—	1	0.7
Other / Not specified	—	—	19	14.0

Participation in sensitization activities

Forty-eight respondents (23.3%) reported attending a sensitization session during the campaign: 43 (20.9%) actively participated in the scheduled animation activities after being informed in advance, and a further 5 (2.4%) participated without having been informed beforehand, suggesting some

spontaneous engagement beyond the directly targeted households. Among those who attended sensitization, 31 followed both thematic modules 1 and 2; 16 followed modules 1 and 3; and 15 followed modules 2 and 3; because some participants attended several sessions, these categories overlap (Table 3).

Table 3. Participation in sensitization activities during the intervention campaign

Indicator	**n**	**%**
Exposure to sensitization sessions (N = 206)		
Attended a sensitization session	48	23.3
Actively participated in session	43	20.9
Participated without prior knowledge	5	2.4
Thematic modules attended (among session participants)		
Module 1 and Module 2	31	—
Module 1 and Module 3	16	—
Module 2 and Module 3	15	—

Note: Thematic module attendance was recorded only for active session participants. Participants could attend several sessions; those who attended all three modules are counted in each pair, so the counts sum to more than the number of participants.

Mosquito aquatic habitats destruction practices

The large majority of respondents, 199 of 206 (96.6%), reported having already destroyed mosquito aquatic habitats at some point (Table 4). Of these, 193 (97.0%) did so at the household level, while 23 (11.6%) participated in collective habitat destruction during the "Journées Ville Propre" community clean-up events organized as part of the campaign. The two modes of action were not mutually exclusive.

Among all 206 respondents, 182 (88.3%) reported having repeated the action of destroying domestic mosquito aquatic habitats since the campaign. Of these, the most common frequency was once per day (n = 91, 50.0%), followed by once every two days (n = 63, 34.6%), once per week (n = 27, 14.8%), and once per month (n = 1, 0.5%). This distribution suggests that habitat destruction became a recurrent domestic practice for the large majority of participating households rather than a single campaign-linked action.

Table 4. Mosquito aquatic habitats destruction practices reported by respondents post-intervention

Indicator	**n**	**%**
Ever destroyed mosquito aquatic habitats		
Yes	199	96.6
No	7	3.4
Mode of habitat destruction (among those who destroyed, n = 199)		
At household level (domestic)	193	97.0
Collectively ("Journées Ville Propre")	23	11.6
Repeated domestic habitat destruction post-campaign (N = 206)		

Yes, repeated the action at home	**182**	**88.3**
No	24	11.7
Frequency of repeated domestic action (among repeaters, n = 182)		
Once per day	91	50.0
Once every two days	63	34.6
Once per week	27	14.8
Once per month	1	0.5

Note: Domestic and collective destruction are not mutually exclusive, respondents could report both. Frequency data available only for the 182 respondents who reported repeating the action at home.

Operational gaps and lessons learned

Despite the positive community uptake, three operational gaps were documented at the capitalization workshop held in October 2023. First, the municipality's equipment for habitat destruction was insufficient to treat every identified site within the intervention zone (Sectors 3 and 4): by endline, 31 of the 134 habitats inventoried there remained active, most of them sites that had persisted since earlier visits (Table 5). Participants noted that scaling the approach to the whole town would require substantially more equipment and time. Second, financial resources for volunteer accompaniment and door-to-door visits were inadequate, limiting the depth of household-level engagement. Third, the 16-day implementation window was too short; participants recommended a minimum of six months for future campaigns to allow full coverage and sustained behavior change. Conversely, the engagement of traditional chiefs and civil society leaders, and the strong SP/Palu-led sector coordination, were identified as the key enabling factors for the mobilization of the 307 volunteers.

Entomology post-intervention evaluation

Effect on mosquito aquatic habitats density and positivity

At baseline (V0, July 2023), a total of 109 mosquito aquatic habitats were identified across the two study zones: 52 in the control zone and 57 in the intervention zone. Habitat types included puddles, ponds, gutters, animal footprints, and small streams, with puddles being the most prevalent in both zones.

At the mid-intervention survey (V1, early September 2023), all baseline habitats were reassessed. In the control zone, which received no intervention, 5 of 52 baseline habitats had disappeared (dried out or destroyed; disappearance rate: 9.6%), with 47 persisting and 55 newly detected, bringing the V1 control total to 102 active sites. In the intervention zone, 34 of 57 baseline habitats had been eliminated (destruction rate: 59.6%), with 23 persisting and 73 newly detected, for a V1 intervention total of 96 active sites. The appearance of new habitats in both zones reflects the dynamic nature of peri-urban larval breeding under active rainy-season conditions.

At the post-intervention survey (V2, October 2023), 107 habitats were inspected in the control zone: 37 of the 102 habitats active at V1 had disappeared and 65 persisted, while the 5 habitats that had disappeared at V1 were again holding water, giving 70 active sites. In the intervention zone, 134 habitats were inspected: 69 of the 96 habitats active at V1 had been eliminated and 27 persisted, the 34 habitats destroyed at V1 were re-inspected and remained eliminated, and 4 newly detected sites were recorded, bringing the V2 intervention total to 31 active sites. Expressed relative to the habitats active at V1, these correspond to a disappearance rate of 36.3% in the control zone and a destruction rate of 71.9% in the intervention zone; denominators are defined in the footnote to Table 5. Across the full study period, the cumulative number of habitats destroyed in the intervention zone reached 103 (34 at V1 + 69 at V2), representing approximately 77% of all sites ever identified in that zone. Habitat

elimination in the intervention zone was consistently and substantially higher than in the control at both V1 (59.6% vs. 9.6%) and V2 (71.9% vs. 36.3%) (Table 5).

Table 5. Larval breeding site dynamics by survey round and zone (V0–V2), Manga 2023.

Round	Zone	Destroyed (n)	Newly detected (n)	Persistent (n)	Total active (n)	Destruction rate (%)
V0-Baseline (July 2023)						
	Control	—	—	52	52	—
	Intervention	—	—	57	57	—
V1-Mid-intervention (early September 2023)						
	Control	5	55	47	102	**9.6%**
	Intervention	34	73	23	96	**59.6%**
V2-One month post-intervention (October 2023)						
	Control	37	0	70	70	**36.3%**
	Intervention	69	4	27	31	**71.9%**

Note: "Persistent" denotes habitats inspected in that round and not found destroyed; "Total active" denotes habitats holding standing water at the time of inspection. Destruction rates are expressed relative to the habitats active at the preceding round (V1: 5/52 and 34/57; V2: 37/102 and 69/96). Denominators therefore differ between columns, and differ from those of the analytical dataset reported in Additional file 1, Table S1, which retains destroyed habitats that were re-inspected to confirm larval absence. At V2, the 34 intervention habitats destroyed at V1 were re-inspected and remained eliminated; in the control zone, the 5 habitats that had disappeared at V1 were again holding water and are counted as persistent. In the control zone, which received no intervention, "Destroyed" denotes habitats found dry or eliminated (by natural drying or residents' own activities).

A total of 587 site-visit observations were analyzed across 241 (107 in control and 134 in intervention) mosquito aquatic habitats, with repeated measurements for the majority of sites. Baseline larval positivity was comparable between study arms (28.8% in control vs 26.3% in intervention; p = 0.80), indicating good balance before the intervention (Figure 2; Additional file 1, Table S1).

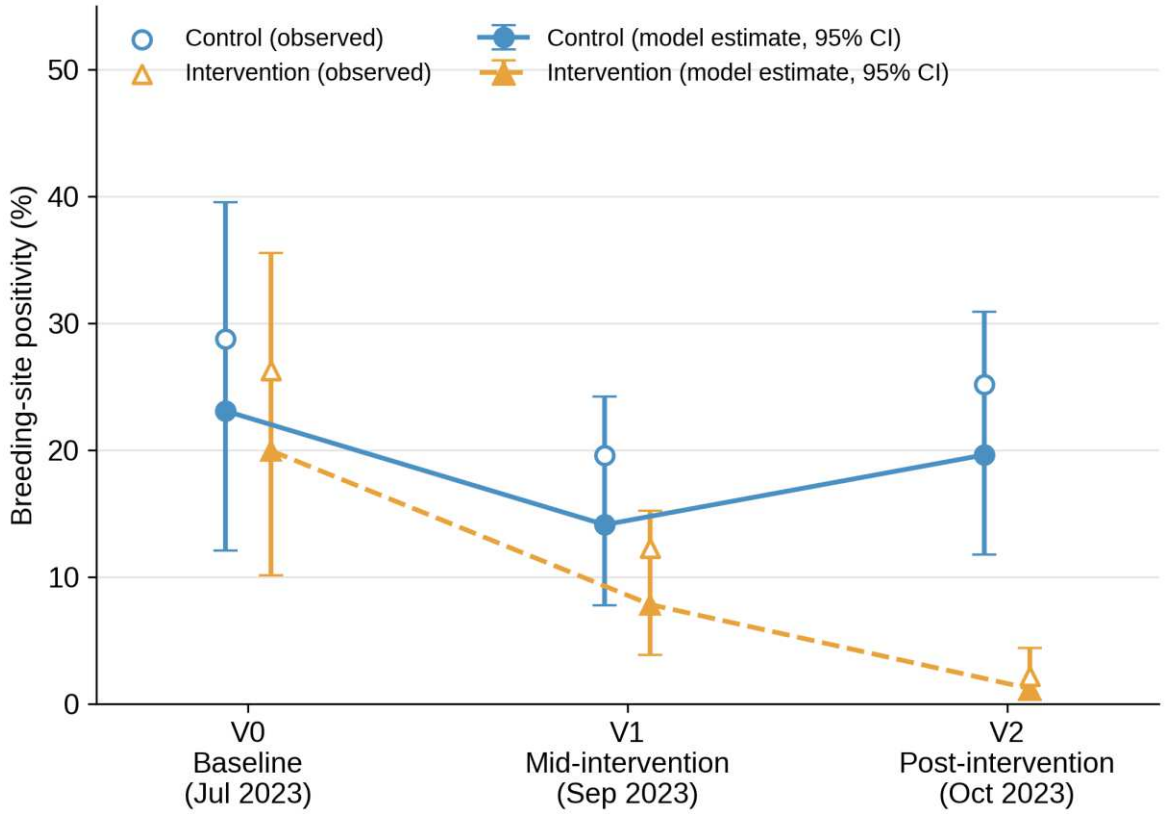


Figure 2. Mosquito aquatic habitat positivity by zone and survey round, Manga, July–October 2023. Open symbols show observed positivity (Additional file 1, Table S1); filled symbols and error bars show model-estimated positivity (estimated marginal means) with 95% confidence intervals from the binomial GLMM (Additional file 1, Table S4). V0, baseline (July 2023); V1, mid-intervention (early September 2023); V2, one month post-intervention (October 2023).

Over time, contrasting trends emerged. In the control arm, positivity decreased initially (28.8% to 19.6% at V1) but rose again to 25.2% at V2, close to its baseline level. In contrast, the

intervention arm demonstrated a continuous decline from 26.3% at baseline to 12.3% at V1 and 2.2% at V2, corresponding to a 91.5% relative reduction from baseline (Additional file 1, Table S6 and Additional file 2, Figure S1).

Mixed-effects logistic regression confirmed a strong intervention effect at the post-intervention time point. At V2, breeding sites in the intervention zone had 95% lower odds of larval positivity compared to control (estimated marginal OR = 0.05, 95% CI: 0.01–0.19, $p < 0.001$), while no significant differences were observed at baseline or mid-intervention (Additional file 1, Table S2 and Table S5; Additional file 3, Figure S2). Sensitivity analysis restricted to habitats holding water at inspection and adjusted for breeding-site type showed an attenuated effect in the same direction: at V2, the odds of positivity remained lower in the intervention zone than in the control zone (estimated marginal OR = 0.16, 95% CI: 0.04–0.65, $p = 0.011$), although the Intervention × V2 interaction was of borderline significance (OR = 0.19, 95% CI: 0.04–1.03, $p = 0.054$; Additional file 1, Table S3).

Model-predicted probabilities supported these findings, showing a decline to 1.2% in the intervention arm versus 19.6% in the control arm at V2 (Additional file 1, Table S4). Overall, these results indicate that the intervention was associated with a reduction in larval positivity, with effects increasing over time.

Effect on adult Anopheles density

Across the three survey rounds, 5461 female mosquitoes were collected, 3460 by human landing catch (HLC) and 2001 by pyrethrum spray catch (PSC). The culicid fauna was dominated by *Culex* spp. (73%), followed by *Anopheles gambiae* s.l. (24%), *Aedes* spp. (2%) and *An. funestus* s.l. (0.5%), with proportions consistent across both collection methods. Mean density of all female mosquitoes and *An. gambiae* s.l. by survey round is presented in Figure 3.

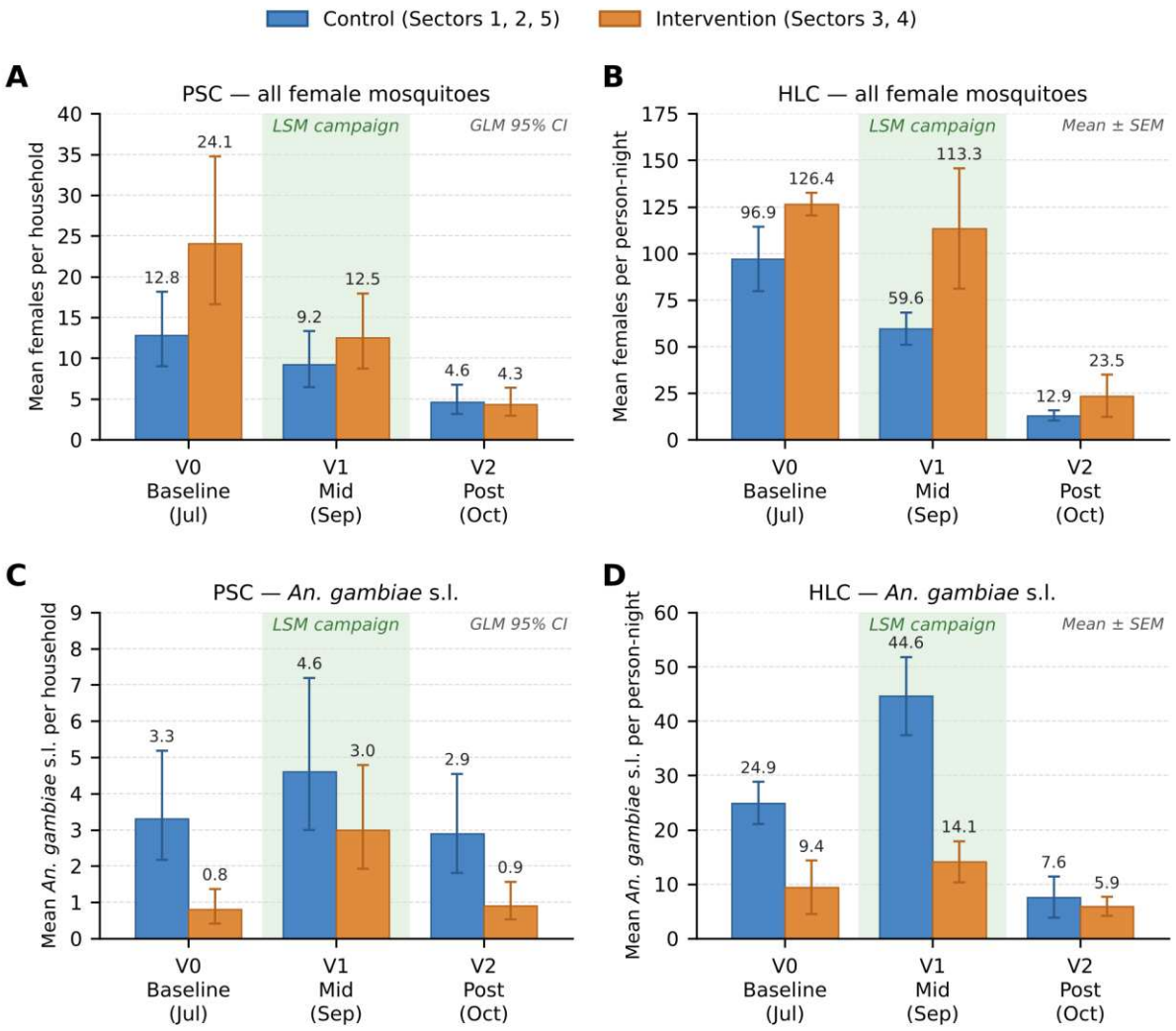


Figure 3. Mean density of female mosquitoes and *An. gambiae* s.l. by survey round and zone. (A) All female mosquitoes, pyrethrum spray catch (PSC; females per household). (B) All female mosquitoes, human landing catch (HLC; females per person per night). (C) *An. gambiae* s.l., PSC. (D) *An. gambiae* s.l., HLC. Manga, Burkina Faso, July–October 2023. Error bars represent 95% confidence intervals from the negative-binomial model (PSC) and ± standard error of the mean (HLC). The shaded band indicates the LSM campaign period. PSC outcomes were analyzed using a difference-in-differences framework (see Methods).

Baseline *An. gambiae* s.l. indoor resting density (PSC) was significantly lower in the intervention zone than in the control (mean 0.75 vs. 3.34 per household; IRR = 0.22, 95% CI: 0.11–0.47; $p < 0.001$), despite comparable larval positivity (26.3% vs. 28.8%, $p = 0.80$). This pre-existing imbalance

motivated the adoption of a difference-in-differences (DiD) framework (see Methods). Total mosquito densities declined substantially in both zones from baseline to endline, by 82% in the intervention zone and 64% in the control, reflecting a dominant seasonal trend as the rainy season subsided. The Zone × Round interaction for total mosquitoes was not significant ($\chi^2 = 3.35$, $p = 0.19$), indicating comparable seasonal trends across zones.

The difference-in-differences (DiD) analysis for *An. gambiae* s.l. (PSC) revealed two distinct patterns (Additional file 1, Table S7; Figure 3). At mid-intervention (V1), the intervention zone showed a disproportionate increase in *An. gambiae* indoor resting density relative to the control (DiD IRR = 2.92, 95% CI: 1.10–7.77; $p = 0.032$), consistent with temporary displacement of host-seeking mosquitoes from disturbed breeding sites toward occupied dwellings. By endline (V2), the DiD estimator was no longer significant (DiD IRR = 1.40, 95% CI: 0.50–3.95; $p = 0.525$), indicating that the differential trajectories of the two zones between baseline and endline did not reach statistical significance, likely reflecting the transient V1 displacement effect that compressed the intervention zone's apparent V0-to-V2 change.

Complementary within-zone analyses of the V1-to-V2 period, the phase during which habitat disturbance effects were expected to translate into adult density reductions, showed a significant 70% decline in *An. gambiae* density in the intervention zone (IRR = 0.30, 95% CI: 0.16–0.56; $p < 0.001$), while the control zone showed no significant change over the same period (IRR = 0.62, 95% CI: 0.30–1.27; $p = 0.192$). This divergent within-zone trajectory is consistent with an intervention effect resolving the transient displacement observed at V1, though it does not constitute a formal DiD test.

The overall global Zone × Round interaction test for *An. gambiae* did not reach significance ($\chi^2 = 4.92$, $p = 0.085$), reflecting the limited statistical power inherent to 180 household-level observations across three rounds and two zones, combined with the non-monotonic response pattern in the intervention zone.

Descriptive HLC trends. Mean *An. gambiae* biting rates per person per night (HLC) rose from V0 to V1 and declined at V2 in both zones, with a proportionally larger mid-intervention increase in the control zone; they therefore did not reproduce the differential increase observed by PSC (Additional file 1, Table S8). In the control zone, biting rates increased from V0 (24.9 per person-night) to V1 (44.6) before declining at V2 (7.6). In the intervention zone, rates increased from V0 (9.4) to V1 (14.1) and declined at V2 (5.9). Given the limited sample size (four house-nights per zone per round), these trends are presented as supportive descriptive evidence only.

Discussion

Mosquito aquatic habitats density and positivity

The larval survey data showed that a community-driven, multisectoral LSM campaign was associated with a substantial reduction in *Anopheles*-positive habitats in a peri-urban West African setting. At endline, the intervention zone had markedly lower odds of larval positivity than the control, with model-predicted positivity declining from 20.0% at baseline to 1.2% post-intervention, while the control zone showed no sustained reduction. The transient decline in larval positivity observed in the control zone at V1 (28.8% to 19.6%) likely reflects seasonal rainfall dynamics, and possible behavioral contamination from the adjacent intervention zone cannot be excluded. However, the subsequent rebound of the control zone to 25.2% at V2, while the intervention zone continued to decline to 2.2%, is consistent with an intervention effect beyond seasonal variation. Physical site destruction rates reached 59.6% at mid-campaign and 71.9% at endline, consistently surpassing the control, in line with findings indicating that sufficient implementation coverage reduces larval presence [36, 37].

Nevertheless, the reappearance of new breeding sites throughout the study period illustrates the ecological constraints of peri-urban LSM during the rainy season. Baseline mapping was conducted during the early rainy season (July), when some habitats may not yet have formed. The new sites

585 detected at V1 (early September) likely reflect seasonal habitat creation driven by peak rainfall rather
586 than incomplete baseline enumeration, as the same systematic survey protocol was applied at both time
587 points across both zones. This interpretation is supported by the parallel appearance of new habitats in
588 the control zone.

589 In Manga, where over 80% of households discharge wastewater onto unpaved surfaces, habitat
590 regeneration was foreseeable. Workshop participants identified six months as the minimum duration
591 for effective control, a threshold consistent with evidence that intermittent campaigns produce only
592 transient vector suppression [38]. The 16-day window was therefore a stress-test of operational
593 feasibility, not a sufficient condition for sustained entomological effect.

594 **Adult vector density**

595 The DiD analysis of adult *An. gambiae* s.l. indoor resting density reveals a more nuanced picture than
596 the larval data. The formal DiD estimator comparing baseline-to-endline trajectories between zones
597 was not statistically significant (IRR = 1.40, p = 0.525), meaning that the overall V0-to-V2 change in
598 the intervention zone did not differ significantly from that in the control when assessed in this standard
599 framework. However, this null result is driven by the transient displacement effect at mid-intervention
600 (V1), during which *An. gambiae* density in the intervention zone increased nearly fourfold, a
601 statistically significant departure from the control zone's trajectory (DiD IRR = 2.92, p = 0.032) and a
602 biologically interpretable consequence of active habitat disturbance forcing host-seeking mosquitoes
603 into nearby dwellings.

604 The post-disturbance trajectory (V1 to V2) provides the clearest indication of a possible intervention
605 effect on adult density. The intervention zone experienced a 70% decline in *An. gambiae* indoor density
606 over this period (IRR = 0.30, p < 0.001), while the control zone showed no significant change (IRR =
607 0.62, p = 0.192). This divergent pattern is consistent with the hypothesis that habitat destruction, once
608 completed, reduced local adult emergence. The global Zone × Round interaction approached but did

not reach significance ($p = 0.085$). The lack of statistical significance in the formal difference-in-differences analysis, despite observable within-zone declines, likely reflects limited statistical power under conditions of high variability, baseline imbalance, and a non-monotonic intervention response.

Baseline *An. gambiae* indoor resting densities were significantly lower in the intervention zone than in the control (IRR = 0.22, $p < 0.001$), despite comparable larval positivity. This discrepancy likely reflects factors operating independently of within-zone larval production. The control zone borders low-lying areas with seasonal water retention outside the study's larval mapping perimeter but within the dispersal range of *An. gambiae* s.l. (1–2 km [19]), potentially contributing adult mosquitoes from external sources, a pattern consistent with evidence that proximity and wind direction relative to larval sites significantly influence local mosquito density [39]. Micro-environmental differences in peridomestic vegetation and proximity to domestic animal resting sites may also have contributed [24]. The DiD framework absorbs this baseline imbalance by design, estimating the intervention effect from differential temporal change rather than absolute zone differences.

These adult-level results should be interpreted alongside the strong larval-level evidence (95% lower odds of positivity at endline, $p < 0.001$). The modest and partially non-significant adult effects are consistent with the short duration (16 days) and physical-only nature of the intervention. In Dar es Salaam, community-based LSM produced durable effects only once it had been institutionalized and maintained over several years [40]. The disconnect between strong larval effects and modest adult effects underscores the need to complement physical destruction with biological larviciding (Bti) in future iterations [41] and to extend the intervention window to cover a full rainy season.

Community engagement: strong uptake, structural barriers to sustained practice

Household survey results were strongly positive: 96.6% of respondents reported having destroyed mosquito aquatic habitats, and 88.3% reported repeating the practice independently, half of them daily. Awareness reached 66.0% of respondents, almost entirely through word of mouth (82.4%), consistent

with a communication strategy designed for a province with low adult literacy, where interpersonal channels mediated by traditional leaders outperformed broadcast media.

Participation was sustained without individual financial incentives, and Ministry of Health endorsement plausibly contributed to the institutional authority underpinning it, although the present design did not test that mechanism. The 50.0% of repeaters reporting daily practice at the post-campaign household survey is encouraging, though the one-month interval between campaign end and survey precludes conclusions about dry-season continuity. The capitalization workshop identified three operational constraints that capped what even a large volunteer workforce could achieve: insufficient municipal sanitation equipment, inadequate accompaniment budgets, and a campaign window too short to treat every habitat within the intervention zone. These constraints are consistent with the 31 habitats still active there at endline, most of which had persisted since earlier visits, and echo findings from Dar es Salaam and Malawi: community mobilization is a real operational achievement, but it cannot substitute for infrastructure and recurrent financing [40, 42].

The CMEP as a governance innovation: feasibility confirmed, institutionalization pending

The CMEP's architecture is noteworthy: nine institutional categories, each assigned an operational role tied to its existing mandate, with sectoral leadership drawn from water management and urban planning rather than health alone. Terms of Reference were developed participatorily and formally endorsed by the Ministry of Health, a level of institutional grounding that comparable multisectoral platforms in the region have rarely achieved [15, 43].

Yet the structural barriers documented in Phase 1 (absent coordination mechanisms, no non-health budget lines, obsolete logistics and limited technical capacity) were only partially addressed. Without defined institutional obligations, intersectoral coordination on vector-borne diseases tends to revert to individual goodwill [44]. Multiple Phase 1 informants independently invoked the HIV response (presidential commitment and a dedicated national secretariat) as the counterfactual for malaria

governance, identifying the absence of equivalent political embedding as the binding constraint, not technical capacity or community willingness. Manga demonstrated that the platform is buildable. What it has not yet secured is the budget line that would make it durable.

From proof of concept to program

The Manga data establish that community-driven LSM is operationally feasible in peri-urban West Africa within a compressed timeframe. A 16-day campaign achieved 71.9% site destruction and a significant reduction in larval positivity. What the data also establish is the ceiling of that approach: breeding sites regenerated continuously, and adult density reduction was modest and partly seasonal.

Closing the gap between feasibility and a sustained program requires three things. Bti-based larviciding is the necessary complement to physical destruction; the evidence base from West Africa, including Burkina Faso, supports its effectiveness at field scale [41, 45]. Dedicated budget lines within municipal and provincial planning cycles must replace dependence on project funding, to ensure continuity of volunteer accompaniment and equipment maintenance. And the intervention window must span at minimum one full rainy season (May–October), matching the habitat regeneration dynamics observed here. The Dar es Salaam Urban Malaria Control Programme, a research project that became a municipally funded service over 14 years, illustrates this institutional trajectory [40]. A comparable path for Manga begins with SP/Palu negotiating dedicated malaria line items in Zoundwéogo Province budgets, supported by the WHO Global Malaria Programme Operational Strategy 2024–2030 [46]. The governance structure, community uptake rates, and entomological effect sizes generated by this study constitute the operational evidence base for that negotiation.

A detailed cost analysis was beyond the scope of this study. However, the intervention relied primarily on volunteer labor (307 community members over 16 days), municipal equipment already available, and coordination costs borne by existing SP/Palu staff. Direct incremental costs were limited to field

supervision, radio broadcasts, and volunteer refreshments. Documenting these costs systematically will be essential for any future scale-up assessment and is planned for the next implementation phase.

Limitations

This study has several limitations. Formal a priori sample size calculations were not conducted, reflecting the pilot nature of the study. The adult density assessment was likely underpowered given high variability and baseline imbalance between zones. The quasi-experimental design with a non-randomized control zone precludes definitive causal attribution; residual confounding by seasonal variation cannot be fully excluded, though the three-round design and zone-specific modeling mitigate this risk [16]. Moreover, the intervention was allocated to a single zone and compared with a single control zone; between-cluster variance could therefore not be estimated, and the reported confidence intervals and p-values are likely anti-conservative. Although entomological sampling points were separated by at least 2 km, behavioral contamination from control-zone residents spontaneously adopting habitat destruction practices cannot be excluded, as the household survey was conducted only in the intervention zone. Collectors and enumerators were not blinded to zone allocation, though the primary outcome, larval positivity, is an objective measure less susceptible to observer bias. The single post-intervention assessment limits conclusions about sustainability, self-reported behaviors may reflect social desirability bias, and the absence of malaria incidence data means that entomological reductions cannot yet be linked to epidemiological effect, the central question for subsequent phases.

Conclusions

This study suggests that a community-driven, multisectoral LSM intervention is feasible in peri-urban Burkina Faso. The coordination platform, established in late 2022, was operationalized within a single rainy season. In Manga, a physical habitat destruction campaign coordinated through the CMEP achieved a 71.9% site destruction rate at endline. A significant reduction in mosquito aquatic habitats positivity was observed in the intervention zone relative to control, whereas the formal difference-in-

differences analysis did not demonstrate an effect on adult indoor resting density. Community uptake was high: 96.6% of surveyed respondents reported having destroyed mosquito aquatic habitats and 88.3% reported sustaining the practice independently after the campaign.

These gains are consistent with an intervention effect, though the quasi-experimental design limits causal inference. Rapid habitat regeneration under rainy-season conditions and the absence of biological larviciding confirm that a single 16-day campaign cannot replace sustained, multi-seasonal implementation. The CMEP (nine institutional categories, a non-health chair and Terms of Reference endorsed by the Ministry of Health) provides a governance model that other districts could adapt for district-level multisectoral coordination. However, its sustainability will depend less on short-term project funding than on the integration of dedicated budget lines within municipal planning frameworks.

Our findings offer field evidence in support of Burkina Faso's national malaria elimination strategy and WHO-TDR multisectoral initiatives across sub-Saharan Africa. The conditions for community-driven LSM can be built in peri-urban West Africa. Further work is required to establish the institutional mechanisms needed to sustain these gains over time.

List of abbreviations

AMBF – Association des Municipalités du Burkina Faso

Bti – *Bacillus thuringiensis* var. *israelensis*

CERS – Comité d'Éthique pour la Recherche en Santé

CI – Confidence interval

CMEP – Comité Multisectoriel pour l'Élimination du Paludisme (Multisectoral Coordination Committee for Malaria Elimination)

CNRFP – Centre National de Recherche et de Formation sur le Paludisme

CNRST – Centre National de la Recherche Scientifique et Technologique

CRSN – Centre de Recherche en Santé de Nouna

DiD – Difference-in-differences

DPES – Direction de la Promotion et de l'Éducation pour la Santé

DPP – Direction de la Promotion du Développement, Ministère de l'Économie et des Finances

DREA – Direction Régionale de l'Eau et de l'Assainissement

GLM – Generalized linear model

GLMM – Generalized linear mixed model

HLC – Human landing catch

INSP – Institut National de Santé Publique

IRR – Incidence rate ratio

IRS – Indoor residual spraying

ITN – Insecticide-treated net

IVM – Integrated vector management

KI – Key informant

LLIN – Long-lasting insecticidal net

LSM – Larval source management

MENAPLN – Ministère de l'Éducation Nationale, de l'Alphabétisation et de la Promotion des Langues Nationales

MUAFH – Ministère de l'Urbanisme, des Affaires Foncières et de l'Habitat

MSA – Multisectoral approach

MSHP – Ministère de la Santé et de l'Hygiène Publique

NGO – Non-governmental organization

OR – Odds ratio

PCR – Polymerase chain reaction

PSC – Pyrethrum spray catch

SD – Standard deviation

SP/Palu – Secrétariat Permanent pour l'Élimination du Paludisme

TDR – Special Programme for Research and Training in Tropical Diseases

UNDP – United Nations Development Programme

UNICEF – United Nations Children's Fund

VBD – Vector-borne disease

WHO – World Health Organization

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (as revised in 2013). The study protocol was reviewed and approved by the Health Research Ethics Committee of Burkina Faso (Comité d'Éthique pour la Recherche en Santé, CERS), Ouagadougou, under reference No. 2022-11-258 MSHP/SG/CERS. The stakeholder consultations of August–September 2022 were initially undertaken with SP/Palu as part of the programmatic set-up of the multisectoral coordination committee, an activity that did not require ethical review. When the joint intervention and its evaluation were planned with the committee members, the study protocol was submitted to the CERS, and approval was obtained before any entomological or household data collection took place in 2023. The CERS approval also covered the secondary use, for research purposes, of the anonymized key informant interview data collected during the August–September 2022 consultations. Before initiating research activities, community consent was obtained by explaining the study's aims and objectives to community leaders in Manga. Written informed consent, including consent for audio recording, was obtained from all key informants, and written informed consent was obtained from all adult household survey respondents. Household respondents aged 15–17 years were enrolled only when they were the household head or the person primarily responsible

for the household. For these participants, written informed consent was obtained from a parent or legal guardian, and assent was obtained from the minor. One respondent aged 17 years was enrolled under these provisions.

Signed informed consent was obtained from all household owners where mosquito collections were conducted, as well as from collectors and supervisors involved in mosquito sampling through PSC and HLC methods. All mosquito collectors and supervisors who participated in the study were provided with free malaria treatment in accordance with the Burkina Faso National Malaria Control Program guidelines.

Clinical trial number

Not applicable. This study is a non-randomized, area-level evaluation of an environmental vector control intervention with entomological outcomes; no participants were assigned to a health-related intervention.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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802 contributions; TDR had no role in data collection, in the statistical analysis, or in the decision to submit
803 the manuscript for publication.

804 **Authors' contributions**

805 WMG, MN, MK, ASa, AO, CSK, LM, FF, AGY and ASi conceived and designed the study. WMG,
806 MN, MK, ASa, GT and AO coordinated and conducted data collection and contributed critical datasets
807 for the analysis. WMG, MN, MK, ASa, AO, CSK, LM and ASi analyzed the data. FF and AGY
808 contributed to the critical review of the manuscript. All authors interpreted the findings. WMG, MN
809 and MK wrote the first draft of the manuscript. All authors critically revised the manuscript, and read
810 and approved the final version.

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814 **Authors' information**

815 Disclaimer: AGY, FF and LM are part of the workforce of the World Health Organization. The authors
816 alone are responsible for the views expressed in this article and they do not necessarily represent the
817 views, decisions or policies of the institutions with which they are affiliated.

818 **Additional files**

819 **Additional file 1: Tables S1–S8 (DOCX)**

820 ***Description:*** Supplementary tables reporting breeding-site positivity by study arm and survey round,
821 the main and sensitivity mixed-effects models, model-predicted positivity and pairwise contrasts,
822 changes in positivity from baseline, the difference-in-differences analysis of An. gambiae s.l. indoor
823 resting density (PSC) and descriptive human landing catch biting rates.

824 **Table S1.** Breeding-site positivity for *Anopheles* larvae, by study arm and survey round.

825 **Table S2.** Odds ratios from the main mixed-effects logistic regression model for breeding-site
826 positivity.

827 **Table S3.** Odds ratios from the GLMM restricted to habitats holding water at inspection and adjusted
828 for breeding-site type.

829 **Table S4.** Model-predicted probability of breeding-site positivity (estimated marginal means).

830 **Table S5.** Pairwise contrasts of intervention vs. control at each visit (odds-ratio scale).

831 **Table S6**. Absolute and relative changes in breeding-site positivity from baseline, by study arm.

832 **Table S7**. Difference-in-differences analysis of *An. gambiae* s.l. indoor resting density (PSC), Manga,
833 July–October 2023.

834 **Table S8.** Descriptive *An. gambiae* s.l. biting rates by human landing catch, Manga, July–October
835 2023.

836

837 **Additional file 2: Figure S1 (TIFF)**

838 **Figure S1.** Relative reduction in breeding-site positivity from baseline, by study arm.
839 ***Description:*** Relative reduction (%) in observed positivity from baseline (V0), by study arm and
840 round. Positive values indicate a reduction relative to baseline. Numerical values are reported in Table
841 S6.

842 **Additional file 3: Figure S2 (TIFF)**

843 **Figure S2.** Forest plot of odds ratios from the main GLMM.
844 ***Description:*** Forest plot of fixed-effect odds ratios (log scale) and 95% confidence intervals from the
845 main mixed-effects logistic model (Table S2). The vertical reference line represents the null effect (OR

= 1). The Intervention × V2 interaction is the only parameter whose 95% CI excludes 1. OR = odds ratio; CI = confidence interval.

References

1. World Health Organization. World malaria report 2024. Geneva: WHO; 2024. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2024. Accessed 13 Oct 2026.

2. Bhatt S, Weiss DJ, Cameron E, Bisanzio D, Mappin B, Dalrymple U, et al. The effect of malaria control on *Plasmodium falciparum* in Africa between 2000 and 2015. Nature. 2015;526:207–11. https://doi.org/10.1038/nature15535

3. Hemingway J, Shretta R, Wells TNC, Bell D, Djimdé AA, Achee N, et al. Tools and strategies for malaria control and elimination: what do we need to achieve a grand convergence in malaria? PLoS Biol. 2016;14:e1002380. https://doi.org/10.1371/journal.pbio.1002380

4. Cook J, Hergott D, Phiri W, Rivas MR, Bradley J, Segura L, et al. Trends in parasite prevalence following 13 years of malaria interventions on Bioko island, Equatorial Guinea: 2004–2016. Malar J. 2018;17:62. https://doi.org/10.1186/s12936-018-2213-9

5. Tusting LS, Willey B, Lucas H, Thompson J, Kafy HT, Smith R, et al. Socioeconomic development as an intervention against malaria: a systematic review and meta-analysis. Lancet. 2013;382:963–72. https://doi.org/10.1016/S0140-6736(13)60851-X

6. Robert V, Macintyre K, Keating J, Trape JF, Duchemin JB, Warren M, et al. Malaria transmission in urban sub-Saharan Africa. Am J Trop Med Hyg. 2003;68:169–76. https://doi.org/10.4269/ajtmh.2003.68.169

7. De Silva PM, Marshall JM. Factors contributing to urban malaria transmission in sub-Saharan Africa: a systematic review. J Trop Med. 2012;2012:819563. https://doi.org/10.1155/2012/819563

8. Sougoufara S, Ottih EC, Tripet F. The need for new vector control approaches targeting outdoor biting Anopheline malaria vector communities. Parasit Vectors. 2020;13:295. https://doi.org/10.1186/s13071-020-04170-7

9. World Health Organization. Larval source management: a supplementary measure for malaria vector control. Geneva: WHO; 2013.

10. Doumbe-Belisse P, Kopya E, Ngadjeu CS, Sonhafouo-Chiana N, Talipouo A, Djamouko-Djonkam L, et al. Urban malaria in sub-Saharan Africa: dynamic of the vectorial system and the entomological inoculation rate. Malar J. 2021;20:364. https://doi.org/10.1186/s12936-021-03891-z

11. World Health Organization. Global technical strategy for malaria 2016–2030, 2021 update. Geneva: WHO; 2021. https://iris.who.int/handle/10665/342995. Accessed 13 Oct 2026.

12. Assefa Y, Van Damme W, Williams OD, Hill PS. Successes and challenges of the millennium development goals in Ethiopia: lessons for the sustainable development goals. BMJ Glob Health. 2017;2:e000318. https://doi.org/10.1136/bmjgh-2017-000318

13. Chanda E, Masaninga F, Coleman M, Sikaala C, Katebe C, MacDonald M, et al. Integrated vector management: the Zambian experience. Malar J. 2008;7:164. https://doi.org/10.1186/1475-2875-7-164

14. Chanda E, Mukonka VM, Kamuliwo M, Macdonald MB, Haque U. Operational scale entomological intervention for malaria control: strategies, achievements and challenges in Zambia. Malar J. 2013;12:10. https://doi.org/10.1186/1475-2875-12-10

15. World Health Organization. Multisectoral approach for the prevention and control of vector-borne diseases: a conceptual framework. Geneva: WHO; 2020.

16. Habicht JP, Victora CG, Vaughan JP. Evaluation designs for adequacy, plausibility and probability of public health programme performance and impact. Int J Epidemiol. 1999;28:10–8. https://doi.org/10.1093/ije/28.1.10

17. World Health Organization, Special Programme for Research and Training in Tropical Diseases. Implementation research toolkit. Geneva: WHO/TDR; 2014.

18. Institut National de la Statistique et de la Démographie. Recensement général de la population et de l'habitation (RGPH 2019). Ouagadougou: INSD; 2021.

19. Costantini C, Li SG, Della Torre A, Sagnon N, Coluzzi M, Taylor CE. Density, survival and dispersal of *Anopheles gambiae* complex mosquitoes in a West African Sudan savanna village. Med Vet Entomol. 1996;10:203–19. https://doi.org/10.1111/j.1365-2915.1996.tb00733.x

20. World Health Organization. Handbook for integrated vector management. Geneva: WHO; 2012.

21. Secrétariat Permanent pour l'Élimination du Paludisme. Rapport annuel de lutte contre le paludisme, Burkina Faso 2022. Ouagadougou: Ministère de la Santé et de l'Hygiène Publique; 2023.

22. Gillies MT, De Meillon B. The Anophelinae of Africa south of the Sahara. 2nd ed. Johannesburg: South African Institute for Medical Research; 1968.

23. World Health Organization. Monitoring and evaluation of indoor residual spraying for malaria vector control. Geneva: WHO; 2016.

24. Tusting LS, Ippolito MM, Willey BA, Kleinschmidt I, Dorsey G, Gosling RD, et al. The evidence for improving housing to reduce malaria: a systematic review and meta-analysis. Malar J. 2015;14:209. https://doi.org/10.1186/s12936-015-0724-1

25. Dabiré KR, Diabaté A, Namountougou M, Toé KH, Ouari A, Kengne P, et al. Distribution of pyrethroid and DDT resistance and the L1014F kdr mutation in *Anopheles gambiae* s.l. from Burkina Faso (West Africa). Trans R Soc Trop Med Hyg. 2009;103:1113–20. https://doi.org/10.1016/j.trstmh.2009.01.008

26. World Health Organization. Global vector control response 2017–2030. Geneva: WHO; 2017.

27. Kirkwood BR, Sterne JAC. Essential medical statistics. 2nd ed. Oxford: Blackwell Science; 2003.

28. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3:77–101. https://doi.org/10.1191/1478088706qp063oa

29. Miles MB, Huberman AM, Saldaña J. Qualitative data analysis: a methods sourcebook. 3rd ed. Thousand Oaks: SAGE Publications; 2014.

30. Guest G, Bunce A, Johnson L. How many interviews are enough? An experiment with data saturation and variability. Field Methods. 2006;18:59–82. https://doi.org/10.1177/1525822X05279903

31. Bates D, Mächler M, Bolker B, Walker S. Fitting linear mixed-effects models using lme4. J Stat Softw. 2015;67:1–48. https://doi.org/10.18637/jss.v067.i01

32. Zuur AF, Ieno EN, Walker N, Saveliev AA, Smith GM. Mixed effects models and extensions in ecology with R. New York: Springer; 2009. https://doi.org/10.1007/978-0-387-87458-6

33. Lenth RV. emmeans: estimated marginal means, aka least-squares means. R package version 1.10.0; 2024. https://CRAN.R-project.org/package=emmeans. Accessed 13 Oct 2026.

34. Angrist JD, Pischke JS. Mostly harmless econometrics: an empiricist's companion. Princeton: Princeton University Press; 2009. https://doi.org/10.1515/9781400829828

35. Hartig F. DHARMa: residual diagnostics for hierarchical (multi-level/mixed) regression models. R package version 0.4.6; 2022. https://CRAN.R-project.org/package=DHARMa. Accessed 13 Oct 2026.

36. Fillinger U, Lindsay SW. Larval source management for malaria control in Africa: myths and reality. Malar J. 2011;10:353. https://doi.org/10.1186/1475-2875-10-353

37. Tusting LS, Thwing J, Sinclair D, Fillinger U, Gimnig J, Bonner KE, et al. Mosquito larval source management for controlling malaria. Cochrane Database Syst Rev. 2013;(8):CD008923. https://doi.org/10.1002/14651858.CD008923.pub2

38. Okumu F, Moore SJ, Selvaraj P, Yafin AH, Juma EO, Shirima GG, et al. Elevating larval source management as a key strategy for controlling malaria and other vector-borne diseases in Africa. Parasit Vectors. 2025;18:45. https://doi.org/10.1186/s13071-024-06621-x

39. Midega JT, Smith DL, Olotu A, Mwangangi JM, Nzovu JG, Wambua J, et al. Wind direction and proximity to larval sites determines malaria risk in Kilifi District in Kenya. Nat Commun. 2012;3:674. https://doi.org/10.1038/ncomms1672

40. Chaki PP, Kannady K, Mtasiwa D, Tanner M, Mshinda H, Kelly AH, et al. Institutional evolution of a community-based programme for malaria control through larval source management in Dar es Salaam, United Republic of Tanzania. Malar J. 2014;13:245. https://doi.org/10.1186/1475-2875-13-245

41. Fillinger U, Lindsay SW. Suppression of exposure to malaria vectors by an order of magnitude using microbial larvicides in rural Kenya. Trop Med Int Health. 2006;11:1629–42. https://doi.org/10.1111/j.1365-3156.2006.01733.x

42. Gowelo S, McCann RS, Koenraadt CJM, Takken W, Van Den Berg H, Manda-Taylor L. Community factors affecting participation in larval source management for malaria control in Chikwawa District, Southern Malawi. Malar J. 2020;19:195. https://doi.org/10.1186/s12936-020-03268-8

43. Roll Back Malaria Partnership. Action and investment to defeat malaria 2016–2030. Geneva: RBM; 2015.

44. Herdiana H, Sari JFK, Whittaker M. Intersectoral collaboration for the prevention and control of vector borne diseases to support the implementation of a global strategy: a systematic review. PLoS One. 2018;13:e0204659. https://doi.org/10.1371/journal.pone.0204659

45. Dambach P, Louis VR, Kaiser A, Ouedraogo S, Sié A, Sauerborn R, Becker N. Efficacy of *Bacillus thuringiensis* var. *israelensis* against malaria mosquitoes in northwestern Burkina Faso. Parasit Vectors. 2014;7:371. https://doi.org/10.1186/1756-3305-7-371

46. World Health Organization. Global Malaria Programme operational strategy 2024–2030. Geneva: WHO; 2024.

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