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BMJ Open

Evaluation of the protective efficacy of Olyset®Plus ceiling nets for reduction of malaria incidence in children in Homa Bay County, Kenya: a cluster-randomized controlled study protocol

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83children in Homa Bay County, Kenya: a cluster-randomized controlled study protocol

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Abstract

Introduction: Malaria is still a major health problem in sub-Saharan Africa, where 98% of global malaria mortality occurs. In addition, the spread of *Plasmodium falciparum* with partial artemisinin resistance in East Africa and beyond is a great concern. The establishment of more effective vector control, in addition to the current long-lasting insecticide-treated net (LLIN) distribution program, is an urgent task in these areas. One novel vector control candidate is the Olyset®Plus ceiling nets which can overcome the problems of variations in net use behaviors and metabolic resistance to insecticide in vectors. Our preliminary study suggests the protective efficacy and high acceptability of this tool. With this proposed second trial, we aim to evaluate the impact of this tool in a different eco-epidemiological setting in the lake endemic region of Kenya.

Methods: A cluster randomized controlled trial is designed to evaluate the impact of Olyset®Plus ceiling nets in Ndhiwa Sub-County, Homa Bay County, Kenya. A total of 44 clusters will be randomly assigned in a 1:1 ratio to the intervention group (Olyset®Plus ceiling nets) and the control group. The assignment will be accomplished through covariate-constrained randomization of clusters. For the primary outcome of clinical malaria incidence, 38 children from each cluster will be enrolled in a cohort and followed for 18 months. We will also evaluate the effects of the intervention on entomological indicators as well as its acceptance by communities and cost-effectiveness.

Ethics and dissemination: Ethics approval was provided by the Mount Kenya University Institutional Scientific Ethics Review Committee. Study results will be shared with study participants and communities, the Homa Bay County Government and the Kenya National Malaria Control Programme. Results will also be disseminated through publications, conferences and workshops to help the development of novel malaria control strategies in other malaria-endemic countries.

Trial registration: UMIN000053873

Keywords

Malaria, *Anopheles* mosquito, vector control, Pyrethroid resistance, Ceiling net, Kenya, Cluster-randomized controlled trial

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3 59 Administrative information
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Title {1}	Evaluation of the protective efficacy of Olyset®Plus ceiling net on reducing malaria incidence in children in the Great Lake Region, Kenya: study protocol for a cluster-randomized controlled trial
Trial registration {2a and 2b}.	UMIN000053873
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Name and contact information for the trial sponsor {5b}	Department of Virology and Parasitology/Research Center for Infectious Diseases, Graduate School of Medicine, Osaka Metropolitan University (OMU), Japan 1-4-3, Asahimachi, Abeno, Osaka, Osaka, Japan, 545-8585 TEL: + 81-6-6645-3760 Website: https://ocuparasitology.com/en/ Directorate of Research and Innovation, Mount Kenya University (MKU), Kenya General Kago Road, Thika, Kiambu, Kenya Website: https://www.mku.ac.ke
Role of sponsor {5c}	OMU will support project management oversight, trial management, data management, statistical analysis, and research governance. MKU also holds overall authority together with project management and analysis.

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Strength and limitations of this study

- This study is a cluster-randomized controlled trial (CRCT) to evaluate the efficacy of the Olyset®Plus ceiling net as a novel vector control tool and a complement to current malaria control tools in sub-Saharan Africa.
- This marks the second CRCT of the Olyset®Plus ceiling net intervention in the lake endemic region of Kenya, expanding the evidence base to a different eco-epidemiological setting from the previous CRCT, where promising results were observed on Mfangano Island.
- Collaboration with local Kenyan institutions such as the Kenya National Bureau of Statistics (KNBS), the National Malaria Control Programme (NMCP), the Kenya Medical Research Institute (KEMRI), and Homa Bay County from the research planning stage is one of the strengths of this trial, allowing for a seamless transition from research implementation in the field to policy development.
- One of the anticipated limitations is the possible contamination between intervention and control clusters because we will not set a buffer zone due to the geographical proximity of each cluster. We will try to account for such contamination effects by integrating spatial data into our statistical model.

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101 Introduction

102 Background and rationale {6a}

103 Malaria is still a major health problem, particularly in sub-Saharan Africa, where 98% of global malaria
104 mortality occurs [1]. Although the morbidity and mortality of malaria declined from the 2000s to 2015
105 owing to many investments and interventions, such as long-lasting insecticide-treated nets (LLINs), malaria
106 rapid diagnostic tests (RDTs), and artemisinin-based combination therapies (ACTs), progress has stalled
107 since 2015. Moreover, the spread of *Plasmodium falciparum* partially resistant to ACT in Africa is an
108 enormous concern. Currently five African countries, Rwanda [3], Uganda [4], Eritrea [5], Ethiopia [6], and
109 the United Republic of Tanzania [2] have reported delayed clearance of *P. falciparum* after treatment with
110 ACTs. Kenya's proximity to these countries highlights the urgent need to establish effective vector control,
111 in addition to maintaining antimalarial drug efficacy and strengthening resistance surveillance.

112
113 Among several vector control measures, LLIN is the most widely adopted tool to prevent mosquito bites and
114 interrupt malaria transmission. However, suboptimal uses of LLIN are key factors in reducing the impact of
115 LLIN on the malaria burden. In the Lake Victoria basin, alternative uses of LLIN for fishing and protecting
116 crops and chicks are well-known local behaviors [7,8]. In fact, in many areas including our study sites in
117 Homa Bay County, Kenya, malaria prevalence remains high despite widespread distribution of LLINs and
118 their periodic replacements for more than a decade. This suggests that LLIN alone is insufficient to interrupt
119 malaria transmission in this region.

120
121 Recently, we have proposed a novel vector control tool that covers the ceiling and the gap between the
122 ceiling and the walls of residential structures with co-formulated pyrethroid and piperonyl butoxide (PBO)
123 bed net material, called the Olyset®Plus ceiling net. The benefit of installing the Olyset®Plus ceiling net in
124 addition to conventional LLINs is detailed elsewhere [9]. Briefly, the Olyset®Plus ceiling net provides a
125 combination of physical and chemical protection against mosquitoes which seek human bloodmeal in the
126 house. Furthermore, the ceiling net is semi-permanently installed and requires no further action from end
127 users, thus its protective efficacy is consistently extended to all who sleep in the house and less affected by
128 the variation in conventional LLIN use.

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5 130 The aim of this study is to evaluate the efficacy, acceptability, and cost-effectiveness of Olyset®Plus ceiling
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7 131 nets on malaria morbidity and transmission in the Lake Victoria basin of Kenya. Preliminary data from our
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9 132 previous study on Mfangano Island in Lake Victoria [9] suggest a substantial reduction in malaria prevalence
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11 133 among school children and high community acceptance of this tool (unpublished data). With this proposed
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13 134 second trial, we aim to evaluate the impact of this tool in a different eco-epidemiological setting with
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15 135 relatively higher malaria transmission, more frequent human and vector movement, and synergistic impact
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17 136 from other interventions such as indoor residual spraying (IRS) and the RTS,S malaria vaccine. Since
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19 137 effective malaria controls need to be tailored to the local context, evidence of the effectiveness of
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21 138 Olyset®Plus ceiling nets from various transmission settings will increase the appeal of this intervention.
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23 139 Furthermore, considering the recent increase in choices of malaria control tools and the necessity of
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25 140 combining various tools to maximize the impact of the malaria control program, it is important to understand
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27 141 the acceptability and cost-effectiveness of each intervention to guide its future deployment.
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31 143 To achieve these objectives, our collaboration with local institutions including the Kenya National Bureau of
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33 144 Statistics (KNBS), the National Malaria Control Programme (NMCP), the Kenya Medical Research Institute
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35 145 (KEMRI), and Homa Bay County, started from the research planning stage. This collaboration is crucial to
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37 146 the seamless transition from field trial to expanded implementation and policy development.
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41 148 **Objectives {7}**
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43 149 The study has four research domains: epidemiology, entomology, social aspects, and cost-effectiveness.
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47 151 For the epidemiology domain, the primary objective is to determine the protective efficacy of Olyset®Plus
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49 152 ceiling net in reducing malaria clinical incidence in children 6 months to 14 years old over 18 months post-
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51 153 intervention. The secondary objectives are (1) to determine the protective efficacy of Olyset®Plus ceiling
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53 154 nets in reducing *Plasmodium* infection prevalence by PCR in all age groups at 6-, 12-, and 18- months post-
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55 155 intervention; (2) to determine the protective efficacy of Olyset®Plus ceiling nets against the time-to-first
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57 156 *Plasmodium* infection; (3) to determine the spillover effects of Olyset®Plus ceiling nets in reducing

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Plasmodium infection prevalence in all age groups at 6-, 12-, and 18-months post-intervention; and (4) to determine the protective efficacy of Olyset®Plus ceiling net in reducing *Plasmodium* infection incidence in children 6 months to 14 years old over 18 months post-intervention.

For the entomology domain, the primary objective is to evaluate the impact of Olyset®Plus ceiling nets on the mosquito density of the primary malaria vector species. The secondary objectives are (1) to determine the impact of Olyset®Plus ceiling nets on entomological inoculation rate (EIR) and (2) to determine the prevalence of knockdown resistance (*kdr*) mutations in vectors.

For the social aspects domain, the primary objective is to assess the determinants of social acceptability of the Olyset®Plus ceiling net in both the intervention and control arms. The secondary objectives are (1) to determine the feasibility of installing the Olyset®Plus ceiling and (2) to determine the appropriateness of fit of the Olyset®Plus ceiling net in the context of households in Ndhiwa Sub-County.

For the cost-effectiveness domain, the primary objective is to determine the incremental cost effectiveness ratios (ICERs) of adding the Olyset®Plus ceiling net to existing malaria control interventions under field trial conditions. The secondary objectives are (1) to establish the relative contribution to costs of the distinct programmatic elements and identify the inputs that contribute the most to overall costs, and (2) to estimate the potential cost of providing Olyset®Plus ceiling net at a larger scale over 3 and 5 years under operational scenarios.

Trial design {8}

The study is an open-label, cluster-randomized controlled trial (CRCT) with 44 clusters evenly divided between the intervention and the control arms. Each cluster will include one or two villages and consist of at least 50 households. A baseline survey will be conducted to determine the pre-intervention *Plasmodium* prevalence and *Anopheles* density, and to collect demographic and socioeconomic data for covariate-constrained randomization of clusters. The baseline survey will be conducted one month before cluster randomization. The post-intervention follow-up period will be 18 months. For the evaluation of the primary

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objective, 38 children aged 6 months to 14 years from each cluster will be recruited and followed for 18 months as a cohort. Cross-sectional surveys will be conducted after 6, 12, and 18 months of the intervention targeting 50 individuals of all ages from each cluster to estimate the overall *Plasmodium* prevalence.

Methods: Participants, interventions and outcomes

Study setting {9}

Location and administrative structure

Ndhiwa (713.5 km²) is one of nine sub-counties in Homa Bay County in Kenya. The sub-county has seven administrative wards: Kanyamwa Kologi, Kanyamwa Kosewa, Kabuoch North, Kwabwai, Kanyadoto, Kanikela, and Kabuoch South/Pala. Based on the number of malaria cases reported in the Kenya Health Information System (KHIS), the accessibility of the site, and population size, we selected Kanyamwa Kologi Ward as the target area (Figure 1). Agriculture is the primary economic activity, with sugarcane as a main commercial crop. County residents also keep animals such as dairy cattle, beef cattle, sheep, goats, and poultry [10]. The ward experiences a long rainy season from March to June and a short rainy season from October to December. As of 2019, the mean annual precipitation is 228.64 mm and the mean annual temperature is 26.7°C. The relative humidity remains elevated year-round, fluctuating between 75% to 85% [11].

Demographics

The population of Kanyamwa Kologi Ward is approximately 33,000 according to the 2019 national census [12]. The dominant ethnic group in the region is Luo and the primary languages are DhoLuo, Kiswahili, and English. There are 172 primary and 36 secondary schools in Ndhiwa Sub-County [13]. Within Kanyamwa Kologi Ward, there are 28 primary and 7 secondary schools.

Malaria epidemiology and control measures

Based on the KHIS, there were 429.1 and 457.2 confirmed malaria cases per 1,000 population in Ndhiwa Sub-County and Kanyamwa Kologi Ward , respectively, in 2023. The primary malaria vector in the sub-county is *Anopheles funestus*, which prefers feeding on humans. *An. arabiensis* is also an important malaria

vector [14]. In Homa Bay County, LLINs have been distributed every three years since the early 2000s, and IRS and the RTS,S malaria vaccine have been piloted in several areas since 2018 and 2019, respectively [15]. Notably PBO-incorporated LLINs (Veeralin®LN, manufactured by VKA Polymers, Tamil Nadu, India) were distributed in late 2023. In Kanyamwa Kologi Ward, there is one level four hospital and seven health centers.

Eligibility criteria {10}

As the ceiling nets are installed per structure, we set the inclusion criteria on a structural basis. The inclusion criteria for the installation of the ceiling nets are (1) residential structures with at least one permanent resident aged 18 years or older in the household, (2) informed consent provided by a resident in the household, and (3) house structure amenable to ceiling net installation in terms of size of the structure, presence of eave, ceiling board, and vertical beams, and material of the top part of the wall. The applicability of the ceiling net installation will be assessed by experienced field staff. The exclusion criteria are (1) vacant structure, confirmed by at least two visits by community health promoters (CHPs), (2) dwelling structure to be vacated or destroyed within the study period, (3) not applicable house structure for the ceiling net installation, and (4) non-residential structures (school, shop, kitchen, storage, and toilet). The inclusion criteria for the prospective cohort are (1) children aged 6 months to 12 years old at the time of enrolment, (2) living in the study area at the time of Olyset®Plus ceiling net installation, (3) having no plan to leave or stay outside the study area for an extended period (longer than one month) over the 18-month follow-up period, and (4) informed consent provided by the participants or the parent or legal guardian. The exclusion criterion is having severe chronic illnesses. The inclusion criteria for cross-sectional malaria surveys for all age groups are (1) living in the study area during the study period, and (2) informed consent being provided by the participants or the parent or legal guardian before each survey. The exclusion criteria are (1) having severe chronic illnesses and (2) pregnancy known at the time of the surveys.

Who will take informed consent? {26a}

Written informed consent will be obtained by the study team members who fully understand the study protocol. After eligibility is confirmed, the study team members will present to the potential participant a

document containing all relevant information about the study in Luo and English. If the participant cannot read, study information will be conveyed verbally in Luo, Kiswahili, and/or English by the study team members. The potential participant will have opportunities to ask any questions. Agreement to participate will be sought only after the participant indicates complete understanding of the study.

Additional consent provisions for collection and use of participant data and biological specimens {26b}

The study information document for ceiling net installation contains the study overview. In addition, the documents for cross-sectional and cohort surveys contain details on collecting, storing, and using personal data and biological specimens during the study.

Interventions

Explanation for the choice of comparators {6b}

In Kenya, LLIN is the most widely used malaria preventive measure. The Division of National Malaria Programme coordinates free LLIN distribution, and the county governments deliver LLINs to residents in all endemic counties every three years. In Homa Bay County, the RTS,S malaria vaccine has been implemented since 2019. The primary purpose of this trial is to demonstrate the superiority in malaria prevention of adding Olyset®Plus ceiling nets to the standard malaria control program. Thus, in the control arm, no Olyset®Plus ceiling nets will be installed, but LLIN use and RTS,S immunization will be allowed in the control and intervention arms as the current best practice. There is no plan for new LLIN distribution during the study period.

Intervention description {11a}

In the intervention arm, Olyset®Plus ceiling nets will be installed in all dwelling units where residents sleep, free of charge to the households. All participants will be encouraged to continue to use LLINs, distributed by the Homa Bay County government. In each intervention cluster, 1 CHP and 2 community volunteers will be recruited from the intervention cluster and another 1 CHP from the control cluster will join the team to enable future knowledge dissemination. The net installation team will be trained to install ceiling nets by skilled local research assistants who participated in previous trials. The head (or another adult) of the

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household eligible to a ceiling net will be notified at least 24 hours before the scheduled installation time. The cost of the ceiling nets and their installation will be covered by the research team. Details of the installation procedure are described in the previous study protocol [9]. Briefly, the ceiling net is a rectangular sheet of Olyset®Plus net with loops sewn along the diagonal seams. The loops are roped to the support beams under the roof and the edges of the net are stapled to the wall.

Criteria for discontinuing or modifying allocated interventions {11b}

As the ceiling net is semi-permanently installed, the intervention will only be discontinued if the participant specifically requests the removal of the ceiling net by the study team. There will be no crossover from the control arm to the intervention arm during the follow-up period. Those who migrate between the arms or emigrate from the study areas will be dropped from the study follow-up.

Strategies to improve adherence to interventions {11c}

Adherence to the intervention cohort in this study is defined as sleeping in houses with Olyset®Plus ceiling nets. Adherence is monitored indirectly by assessing the number of nights each participant spends outside their house during the bi-weekly interview. During each house visit, CHPs will visually inspect the condition of the ceiling nets. Any visible tear and damage to the ceiling net will be reported to the research team, who will assess the size and location of the damage and perform repair or replace the ceiling net if necessary.

Relevant concomitant care permitted or prohibited during the trial {11d}

There is no specific concomitant care prohibited during the trial. All participants in both arms will continue to receive and use free LLIN and have access to standard medical care, including malaria testing by RDT, treatment with ACT and RTS,S malaria vaccination.

Provisions for post-trial care {30}

All participants will be under the normal healthcare system in the study setting. No perceived health risks for the intended population are expected with the intervention. Our plan of continuous cross-sectional malaria surveillance after the study period allows us to monitor further parasite transmission in the population.

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5 298 **Outcomes {12}**
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7 299 Epidemiological domain: The primary outcome will be symptomatic malaria case incidence, defined as
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10 300 axillary temperature of $\geq 37.5^{\circ}\text{C}$ or a history of fever in the preceding 48 hours, and positive mRDT, in
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13 301 children aged 6 months to 14 years enrolled in the cohort, monitored with biweekly visit and passive case
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15 302 detection in the health facilities during an 18-month follow-up. The secondary outcomes will be (1) the
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17 303 prevalence of *Plasmodium* infections by PCR in all age groups at 6, 12, and 18 months post-intervention, (2)
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19 304 time to first infection defined as the number of days between the start of the intervention and the first PCR
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21 305 positive diagnosis in the cohort of children during the 18-month follow-up period, (3) spillover effect
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23 306 measured with the above-mentioned prevalence parameter, and (4) infection incidence by PCR in the
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25 307 prospective cohort of children aged 6 months to 14 years over 18 months.
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27 308
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29 309 Entomological domain: The primary outcome will be the density of the primary malaria vectors, species
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31 310 composition and sporozoite infection rates. Malaria vector density will be determined using CDC light trap,
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33 311 and species composition and sporozoite infection rates will be determined by microscopy and PCR. The
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35 312 secondary outcomes of the entomology domains will be (1) changes in EIR as a measure of malaria
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37 313 transmission and (2) prevalence of *kdr* mutations associated with insecticide resistance in *Anopheles*
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39 314 mosquitoes captured by light trap.
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44 316 Social aspect domain: The primary outcome will be the percentage of households consenting to Olyset®Plus
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46 317 ceiling net installation when offered. In addition, we will include observations and discussions about
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48 318 individual attitudes toward the ceiling net. The secondary outcomes of the social aspect domain will be the
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50 319 percentage of the intact ceiling net, description of damaged net, and the impact on the living environment at
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52 320 6, 12, and 18 months post-intervention.
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56 322 Cost-effectiveness domain: The primary outcome will be the incremental cost-effectiveness of adding
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58 323 Olyset®Plus ceiling net to existing malaria control interventions under field trial conditions from the societal
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and provider perspectives. The secondary outcomes of the cost-effectiveness domains will be (1) the costs of the distinct programmatic elements and the inputs that contribute the most to overall costs, and (2) the cost of providing Olyset®Plus ceiling net at a larger scale over three and five years under operational scenarios.

Participant timeline {13}

The schedule of trial activities is presented in Figure 2. The detail of each survey is described in Figure 3.

Sample size {14}

The sample size was calculated using the method of Hayes and Moulton [16]. All the sample sizes will be recalculated based on the baseline data, which will be collected about one month before the ceiling net installation.

Epidemiological survey

The following calculations were based on the historical data collected from the Lake Victoria region in Kenya with a clinical malaria incidence rate of 0.5 per person-year in children under 14 years old by RDT (unpublished data on Mfangano island), 40% parasite prevalence for all age groups by PCR and a between-cluster coefficient of variation (CV) in incidence rate of 0.24 in both groups. In the study site, RTS,S malaria vaccination began in 2019, with a mass distribution of PBO-incorporated LLINs at the end of 2023. Therefore, the intervention effect is expected to be smaller than those in previous studies and is conservatively assumed to be 25%. Assuming 38 individuals per cluster to be followed for up to 18 months with 20 % loss-to-follow up rate, we require 22 clusters per arm to achieve 80% power to detect a significant incidence rate ratio of 0.75 (25% protective efficacy) at a two-sided type 1 error of 5%. With the number of clusters with 50 individuals per cluster, for the secondary outcome of malaria prevalence by PCR for all age groups, we would achieve 5% type 1 error and 80% power to detect 23.5 % relative reduction. We do not specify the sample size for identifying spillover effects because spillovers tend to have smaller effect sizes relative to total or overall effects, so typically larger sample sizes are required to detect them. Although our study may be underpowered to detect spillovers, we will report the results as an exploratory analysis.

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Entomological survey

Based on the previous study, we assume a mean vector density (number of mosquitoes per CDC light traps) of 3.3, a standard deviation (SD) of 3.3, and CV of 0.192. For 80% power to detect a 50% decrease in mean mosquito densities at 5% type 1 error level, we need to capture mosquitoes from five houses per cluster.

Recruitment {15}

Thirty-eight eligible children in each cluster will be randomly recruited into our cohort . Recruitment will be limited to children aged 12 or younger, to avoid children aging out during the 18-month monitoring period. Study team staff will obtain informed consent from the parents or caregivers of the children before enrolling the children in the cohort. For the cross-sectional survey at each time point, we will randomly select from each cluster 50 individuals of all age groups . To guarantee the representativeness for all age groups, the selection will be done with following age category stratifications; 0-4, 5-9, 10-14, 15-19, and 20 and above.

Assignment of interventions: allocation

Sequence generation {16a}

Random numbers will be generated using the sample function in R software.

Concealment mechanism {16b}

The individual, household, and villages (clusters) are all given unique IDs at the beginning of the baseline. Any following steps handle only these anonymized IDs.

Implementation {16c}

After the baseline survey, covariate-constrained randomization will be used to allocate the 44 clusters across the two study arms. The following factors will be constrained: baseline malaria infection prevalence by RDT in children aged 0.5–14 years, LLIN usage, malaria vaccine coverage, socioeconomic status (SES), population size, the proportion of eligible houses for the ceiling net installation, and vector densities. An independent statistician will perform the randomization. Local study assistants will perform participant

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enrollment.

Assignment of interventions: Blinding

Who will be blinded {17a}

Due to the visibility of the Olyset®Plus ceiling net, neither the trial participants nor the members of the study team who take part in field activities can be blinded. However, laboratory- and office-based personnel (e.g., microscopists, laboratory technicians, and data analysts) will be blinded to the identity and intervention status of the trial participants since all biological specimens will be identified by a unique numeric study identifier, and personal information will be removed before analyses.

Procedure for unblinding if needed {17b}

This is an open-label trial, and only the data measurers are blinded. Therefore, there is no circumstance that they need to be unblinded.

Data collection and management

Plans for assessment and collection of outcomes {18a}

Baseline survey

A baseline survey targeting 50 enumeration areas (comprising one or two villages) in the study area will be conducted shortly before the ceiling net intervention to obtain data to assure the balance of the cluster allocation and obtain basic demographic data. The baseline survey includes a questionnaire for all households, mRDT testing of all children aged 6 months to 14 years, and an entomological survey of randomly sampled households. We modified the questionnaire used in the 2020 Kenya Malaria Indicator Survey (KMIS) mainly to quantify the SES of each household and bed net usage. In addition, we add questions to quantify the favorability of ceiling nets before the intervention.

Cohort monitoring

Incidence of clinical malaria in the prospective cohort will be estimated by both active and passive case

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3 406 detections. For active case detection, we will conduct home visits every two weeks. Axillary temperature
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5 407 will be measured using a digital thermometer. Participants with fever ($>37.5^{\circ}\text{C}$) or other malaria-related
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7 408 symptoms listed in the Kenya National Malaria Treatment Guideline at the time of home visit or within the
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9 409 previous 48 hours will be tested for malaria by RDT. History of travel, confirmed malaria episode, and visit
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11 410 to local health facilities since the previous visit is recorded. *Plasmodium* infection status will be determined
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13 411 by RDT and PCR from all cohort participants during every other biweekly home visit i.e. every four weeks.
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15 412 For passive case detection, we ask all cohort participants to visit designated health facilities in case they
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17 413 suspect malaria between home visits. The designated facilities are asked to record all malaria tests performed
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19 414 regardless of their results together with the cohort ID. The cost of RDT and anti-malarial treatment will be
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21 415 covered by the research team to encourage cohort participants to use only designated facilities.
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26 417 *Cross-sectional malariometric surveys*
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28 418 Malaria prevalence in children and adults will be estimated using cross-sectional malariometric surveys in
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30 419 communities. These surveys will be conducted at 6, 12, and 18 months post-installation. Community surveys
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32 420 will be conducted by house visits.

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35 421 *Plasmodium* infection status will be determined using three methods: RDT, microscopy, and PCR. A finger-
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37 422 prick blood sample will be collected for on-site diagnosis using the Bioline Malaria Ag P.f/Pan RDT (Abbott
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39 423 Diagnostics Korea Inc., Republic of Korea). Survey participants with positive test results will be provided
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41 424 with a treatment course of artemether-lumefantrine with dosing instructions in accordance with guidelines
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43 425 from the Ministry of Health in Kenya after checking their recent treatment history. Blood smears will be
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45 426 prepared on site and transported to the main laboratory in Homa Bay where thin smears are fixed with
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47 427 methanol and all smears are stained with 3% Giemsa solution for 30 minutes, then examined by experienced
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49 428 microscopists. Two blood samples (70 μl each) will be collected with a 75-mm heparinized micro-hematocrit
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51 429 capillary tube (Thermo Fisher Scientific, MA, USA) and spotted on Whatman ET31 Chr filter paper
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53 430 (Whatman International. Maidstone, UK). The blood samples will be allowed to dry at ambient temperature
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55 431 and stored in individual zipped plastic bags at -20°C . The dried blood spots will be used for the determination
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57 432 of malaria status by PCR [17].
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Entomological surveys

Indoor resting mosquitoes will be collected from five sentinel houses within each cluster using the CDC light trap method. Samples will be preserved in 96% ethanol and placed in a cool box with ice. Specimens will be examined for sex determination by microscopy and species identification by microscopy and PCR. Indoor resting mosquitoes will be collected at baseline, 6, 12 and 18 months post ceiling net installation.

Social aspects

We will conduct an exploratory sequential research design using integrated mixed methods (qualitative and quantitative). Qualitative assessment of community perceptions on the Olyset®Plus ceiling nets, community facilitators, and concerns of Olyset®Plus ceiling net use will be implemented, followed by quantitative assessments every 6 months and routine monitoring to evaluate durability and appropriateness of fit of Olyset®Plus ceiling nets using observation checklists. At the end of the study, other qualitative case studies, such as focus group discussions and key informant interviews, will be conducted to document success stories and inform the sustainability and scalability of the intervention.

Cost-effectiveness analysis

Incremental financial and economic cost data of Olyset®Plus ceiling net will be collected alongside the intervention. In cases where resources, such as staff, are shared among multiple elements, the allocation of costs will be carried out using an appropriate proxy. Costs related to research activities will be excluded from this allocation. Financial costs will be derived from project expenditure records, while economic costs, which encompass financial expenditures and donated resources, will be identified through project records and social aspects activities. The value of donated resources will be credited based on prevailing market rates. Furthermore, capital costs will be annualized over their useful life for financial costing and annualized at a discount rate of 3% for economic costing.

Plans to promote participant retention and complete follow-up {18b}

All surveys planned for the epidemiological and entomological domains will be conducted by house visits. CHPs will make an appointment with eligible participants before each visit to confirm the participants'

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3 462 available date and time. Small remunerations will be provided to survey participants to compensate for their
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5 463 time. CHPs will receive detailed instructions and participatory training for all field procedures and will be
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7 464 actively supervised by the research team throughout the duration of the study. Feedback will be regularly
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9 465 sought from CHPs regarding any issues raised by study participants, and discussions will be held to resolve
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11 466 issues from the field.
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16 468 **Data management {19}**

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19 469 All data from the baseline, cohort, and cross-sectional surveys will be captured using the Research Electronic
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21 470 Data Capture (REDCap) software on electronic tablets. Data will be uploaded daily to a highly secure server
22
23 471 hosted by Mount Kenya University (MKU). All data from the quantitative surveys will also be stored
24
25 472 securely and backed up regularly to prevent data loss. Data access and management of databases will be
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27 473 limited to authorized study investigators and collaborators. After validation of data uploaded to the MKU
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29 474 server, data stored locally on the tablet computers will be permanently deleted to minimize unauthorized
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31 475 access.
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36 477 **Confidentiality {27}**

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38 478 To maintain confidentiality, each participant in cross-sectional surveys, the longitudinal cohort, and the
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40 479 quantitative surveys is assigned a unique identifier. The data collected will be labelled using the unique
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42 480 identifier and stored separately from the key linking personal information (name, date of birth, GPS of each
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44 481 household, and phone number). The data will be kept on a secure server that is only accessible to the
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46 482 research staff. Publications will contain only aggregated data, and no personal information will be included.
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50 484 **Plans for collection, laboratory evaluation and storage of biological specimens for genetic or molecular**
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52 485 **analysis in this trial/future use {33}**

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54 486 Anonymized blood samples from study participants will be stored and analyzed for *Plasmodium* infections
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56 487 by microscopy and PCR in our laboratory in Homa Bay. Microscopic examinations of adult mosquito
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58 488 specimens will be conducted in our field laboratory in Mbita, while PCR analyses will be conducted in our
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laboratories in Homa Bay and MKU. Laboratory data outputs will be entered in Microsoft Excel and imported into the database. No human genetic analysis is planned for this study. However, remaining biological materials will be stored indefinitely for future studies unless the participants opt out during the informed consent process. Participants are provided with contact information of the research team and can remove themselves from this study or any future studies at any time without penalty or prejudice.

Statistical methods

Statistical methods for primary and secondary outcomes {20a}

We will follow the CONSORT guidelines extended for CRCT for statistical analysis and result reporting. The intention-to-treat (ITT) analysis is the primary analysis approach for both the primary and secondary objectives for the epidemiological and entomological studies. The per-protocol (PP) analysis is included as a supplementary analysis for the primary and secondary objectives for the epidemiological and entomological studies. Detailed methodologies for the epidemiological part are described in the supplementary file of statistical analysis plan.

Clinical malaria incidence

We will determine the protective efficacy of Olyset®Plus ceiling nets against malaria case incidence by comparing clinical malaria incidence rates between arms. We will use mixed effects negative binomial regression accounting for within-cluster correlation of outcomes. Possible confounding factors such as age, sex, bed net usage, house structure, malaria vaccination history, and SES will be adjusted as well as covariates used in the covariate-constrained randomization. In addition, because we will not set a buffer zone, the distance to the nearest household in the other arm will be adjusted in the following analysis to reduce the contamination between two arms. The variable was selected from the previous study [18].

Prevalence of malaria infection

The secondary outcome, the prevalence of malaria infection by PCR and microscopy measured at 6, 12, and 18 months after the ceiling net installation will be analyzed using mixed effects logistic regression adjusting for the above-mentioned confounding factors.

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5 518 *Time to first malaria infection*
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7 519 A Cox proportional hazards model and other survival models will be used to compare time to first malaria
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9 520 infection between arms adjusting for the above-mentioned confounding factors. In addition, we will account
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11 521 for the within-cluster correlation of responses.
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16 523 *Exploratory analysis for spillover effects*
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18 524 Evidence for positive spillover effects of the ceiling net on malaria infection prevalence of all age group will
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20 525 be assessed by comparing individuals with no intervention conditioning 1) the distance to ceiling net
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22 526 installed household, and 2) the coverage of surrounding households with ceiling net within 400 m. The
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24 527 distance of 400 m was chosen as the spillover effect appears to attenuate at this distance based on previous
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26 528 reports [19].
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30 530 *Entomology*
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32 531 Differences in vector density and EIR between arms will be evaluated by random effects negative binomial
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34 532 regression taking into account the intracluster correlation.
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38 534 *Social aspects*
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40 535 We will employ the Framework for Reporting Adaptations and Modifications to Evidence-based
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42 536 Implementation Strategies (FRAME-IS) [20] to document the implementation processes of the ceiling nets,
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44 537 and the Evidence integration triangle framework[21] to align the evidence generated to policy and vector
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46 538 control strategies from the health systems aspect. The theoretical framework in qualitative research will be
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48 539 grounded theory[22]. Data from ethnographic, focus group discussions, key informant interview will be
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50 540 summarized using content thematic analysis. Pre- and post-intervention acceptability to install Olyset®Plus
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52 541 ceiling net intervention will be compared to actual consent using logistic regressions.
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56 543 *Cost-effectiveness*
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The economic and financial costs associated with the Olyset®Plus ceiling net intervention will be presented in total and disaggregated forms, highlighting the relative contribution of each program element to the overall program costs. To facilitate comparisons with other malaria vector control interventions, the costs will be converted into cost per household and per person receiving the intervention annually. Various program scenarios, such as different scales and durations, will be presented to estimate operational implementation costs. Compared to the control group, we will utilize the number of malaria cases averted in the Olyset®Plus ceiling net arm to calculate the DALYs averted using standard methods.

Interim analyses {21b}

No interim analysis is planned because neither the insecticide permethrin nor the synergist PBO as formulated in Olyset®Plus LLINs are known to pose significant health and safety risks [9,23].

Methods for additional analyses (e.g. subgroup analyses) {20b}

We will perform the same analysis for three age subgroups (≤ 59 months old; 5 years old to 14 years old; 15 years old or older) to examine if the effects of Olyset®Plus ceiling net differ by age groups. In addition, we will perform other machine learning based approach such as causal forest and super learner to estimate the conditional average treatment effect.

Methods in analysis to handle protocol non-adherence and any statistical methods to handle missing data {20c}

In the cohort, non-adherence to the intervention can be identified by bi-weekly interviews. Participants who regularly sleep outside their homes will be removed from the analyses. The extent and patterns of missing data will be assessed once all data collection has been completed. If necessary, we will apply simple hot-deck imputation methods if the missing fraction for the covariate is $<5\%$ or appropriate multiple imputation approaches if the missing fraction for a covariable are $\geq 5\%$. If a non-ignorable portion of the subjects have missing values on a covariate (due to missing at random or missing completely at random), that covariate may be excluded in the model.

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Plans to give access to the full protocol, participant level-data and statistical code {31c}

This manuscript is the full protocol. The corresponding author will make the de-identified datasets or any future statistical code available upon reasonable request.

Oversight and monitoring

Composition of the coordinating centre and trial steering committee {5d}

The sampling team, composed of CHPs and laboratory technicians, set up a day-to-day communication group and exchanged their experiences. A local management team of study investigators from Kenya and Japan also joined this, leading and advising the activities and monitoring the sample and data integrity. A monthly meeting will be held by the steering committee composed of all key researchers from Kenya and Japan, including the principal investigator (PI) and co-PI, which aim to monitor the progress of the trial.

Composition of the data monitoring committee, its role and reporting structure {21a}

Because this intervention is considered to be of a low-risk nature, this study does not have a data monitoring committee. For additional credibility about study quality, the researchers will consult a third statistician, if necessary.

Adverse event reporting and harms {22}

All unanticipated problems will be reported to the research team and Homa Bay County Ministry of Health (MOH) through CHPs. Medical officers from Homa Bay County will assess the relatedness of the reported events to the study and report to the research team, including the PI. In the event of a study-related serious adverse event, the study team will convene a meeting immediately with the MOH and Homa Bay County Teaching and Referral Hospital representatives to review the case and take necessary action. Also, the ceiling net is made of the same materials and chemicals as LLIN already on the market, and is therefore not expected to have significant environmental impact.

Frequency and plans for auditing trial conduct {23}

A monthly meeting will be held during the follow-up period to ensure that all surveys and investigations are

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conducted according to the study protocol. The study is required to submit annual reports and renewal to ethical review boards of Osaka Metropolitan University, Japan, and Mount Kenya University, Kenya.

Plans for communicating important protocol amendments to relevant parties (e.g. trial participants, ethical committees) {25}

Decisions on important trial amendments must be made through a formal procedure and will be approved by institutional review boards (IRB) at Mount Kenya University and Osaka Metropolitan University. The protocol in the clinical trials registry will also be updated accordingly.

Dissemination plans {31a}

Study results will be shared with the study participants and communities, the Homa Bay County Government and the Kenya National Malaria Control Programme. Results will also be disseminated through publications, conferences and workshops to help the development of novel malaria control strategies in other malaria-endemic countries. Suggestions from the participants will also help shape the future improvement of the intervention.

Discussion

Global malaria progress has flatlined in recent years: targets of reductions in malaria morbidity and mortality and required funding by 2030 are all off track as of 2023[6]. In addition, *P. falciparum* with partial artemisinin resistance, which has been a problem in the Great Mekong Subregion (GMS) for more than a decade [24] [2–6]. Novel interventions that are cost-effective and widely accepted by local communities are urgently needed to contain the spread of artemisinin-resistant *P. falciparum* in sub-Saharan Africa.

Early results from our cluster randomized controlled trial of Olyset®Plus ceiling nets on Mfangano Island in Lake Victoria, Kenya suggest that ceiling nets can reduce *Plasmodium* prevalence and are positively received by the local communities. Nevertheless, there are regional differences in housing design, vector abundance and composition, and availability of malaria control interventions. As such the feasibility and acceptability of the ceiling net intervention are likely to depend on local eco-epidemiological context [25].

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3 628 Furthermore, one of the secondary objectives in this study is to measure the spillover effects, i.e. how much a
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5 629 household that does not have a ceiling net benefits from living near a house with a ceiling net. This enables a
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7 630 broader understanding of the impact of the ceiling nets at the community level.
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11 632 This trial has several limitations. First, although the study is designed as a cluster-randomized controlled
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13 633 trial, contamination between intervention and control clusters cannot be excluded, as buffer zones between
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15 634 intervention and control clusters cannot be created due to geographic proximity of houses and villages in the
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17 ward. A recent study, however, has shown that the spillover effect of interventions on malaria can extend to
18 635 3 km [26], so buffer zones of a few hundred meters, as set out in many studies, may not be sufficient. We
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20 636 will try to eliminate such contamination effects by integrating spatial data into our statistical model. Second,
21
22 637 because of the visible nature of the ceiling net, we cannot exclude open-label and observer biases. It is
23
24 638 conceivable that participants receiving ceiling nets may reduce their usage of conventional LLIN, as both
25
26 639 interventions are made of the same materials and may be perceived to protect against malaria in the same
27
28 640 manner. We aim to reduce such bias as much as possible through repeated reminders by CHPs that ceiling
29
30 641 nets serve as an addition to and not a replacement of conventional LLINs. We will conduct surveys and in-
31
32 642 depth interviews to elicit participants' perceptions of the ceiling net, which can guide future messaging and
33
34 643 implementation. To reduce observer bias, laboratory investigators and data analysts will be blinded. Third, in
35
36 644 the study area, pyrethroid+PBO-incorporated LLINs were distributed in 2023. It may reduce the effect of our
37
38 645 ceiling net intervention because pyrethroid+PBO-incorporated LLINs are more effective than non-PBO-
39
40 646 incorporated LLINs by targeting both *Anopheles* vectors with and without metabolic resistance to
41
42 647 pyrethroids. Pyrethroid+PBO incorporated LLINs received a conditional endorsement from the World
43
44 648 Health Organization (WHO) in 2017, and approximately half of the LLINs distributed in sub-Saharan Africa
45
46 649 in 2022 were of this type [2]. Given the abundance of PBO-incorporated LLINs in the region, it is important
47
48 650 to assess the effectiveness of the Olyset®Plus ceiling net as an addition to these LLINs to inform policy
49
50 651 recommendations. Recently LLINs combining two different classes of insecticides have been shown to be
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52 652 superior to pyrethroid-based LLINs [27]. When these new LLINs become widely available, the effectiveness
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54 653 of pyrethroid-PBO ceiling nets needs to be re-investigated.
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Trial status

The Baseline survey was started on April 8, 2024. The recruitment of the intervention participants will be in June 2024. The current protocol is version 5.0 as of April 18.

Abbreviations

ACT: artemisinin-based combination therapy

CHP: community health promoter

CRCT: cluster-randomized controlled trial

CV: coefficient of variation

kdr: knockdown resistance

KHIS: Kenya Health Information System

ITN: insecticide treated nets

IRS: indoor residual spraying

LLIN: long-lasting insecticidal nets

MKU: Mount Kenya University

PBO: piperonyl butoxide

RDT: rapid diagnosis tests

Declarations

Acknowledgements

We would like to express our sincere gratitude to this study's participants, field, and laboratory staff. In addition, we acknowledge the collaboration and support of health offices in Homa Bay County, Kenya.

Authors' contributions {31b}

AK and JG are co-principal investigators. YKK, WK, and AK developed the original concept. All authors discussed and contributed to the study protocol. YKK, WK, PO, BM, TO, CWC, JK, SM, and MK drafted the manuscript. YKK, WK, CWC, MK, GO, and JG contributed to the revisions of the draft of the

1
2
3 683 manuscript. DY participated as a senior statistician. YKK and MK drafted the statistical analysis plan (SAP)
4
5 684 and WK, CWC, and DY revised. The authors read and approved the final manuscript and SAP.
6
7 685

9 686 **Funding {4}**

11 687 YKK and MK were financially supported by the Japan Society for the Promotion of Science. AK and JG
13
14 688 received support from JICA/AMED joint research project (SATREPS) (Grant no. 20JM0110020H0002),
15
16 689 Hitachi Fund Support for Research Related to Infectious Diseases, and Sumitomo Chemical Corporation.
17
18 690 The funding bodies play no role in the study design, data collection, analysis, interpretation, and publication.
19

22 692 **Availability of data and materials {29}**

24 693 The study regimes, consent forms, assent forms, and study-related materials are accessible from the
25
26 694 corresponding author. The final trial dataset will be available to all investigators. The corresponding author
27
28 695 will make the de-identified datasets and source codes for all analysis available upon reasonable request.
29

33 697 **Patient and public involvement**

35 698 Although the study design was developed through discussions among the researchers, consultations with the
36
37 699 local population were conducted prior to initiating the baseline survey, and their input was incorporated into
38
39 700 the study. Community involvement will also be ongoing during the implementation of interventions and
40
41 701 research activities.
42

45 703 **Ethics approval and consent to participate {24}**

47 704 Ethics approval was received from Mount Kenya University Institutional Scientific Ethics Review
48
49 705 Committee (MKU-ISERC) and is under the review from the Ethics Committee in Osaka Metropolitan
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51 706 University.
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54 707 Written informed consents will be sought from study participants before the baseline survey, installation of
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56 708 ceiling nets, each cross-sectional survey, and the start of prospective cohort surveys. Participants have the
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58 709 right to withdraw from the study at any time, and the option to withhold previously collected samples from
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60 710 any future analyses and studies.

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The samples collected in this study may potentially be used for other research purposes. This is clearly stated in the informed consent form. In such cases, we will obtain the necessary ethical approval and provide participants with the chance to opt-out from this. All experiments will be carried out in adherence to WHO requirements and the Declaration of Helsinki.

Consent for publication {32}

We will not present identifying images or other personal or clinical details of participants. The participant information materials and informed consent form are available from the corresponding author on request.

Competing interests {28}

This study was partially supported by a research grant from Sumitomo Chemical Corporation.

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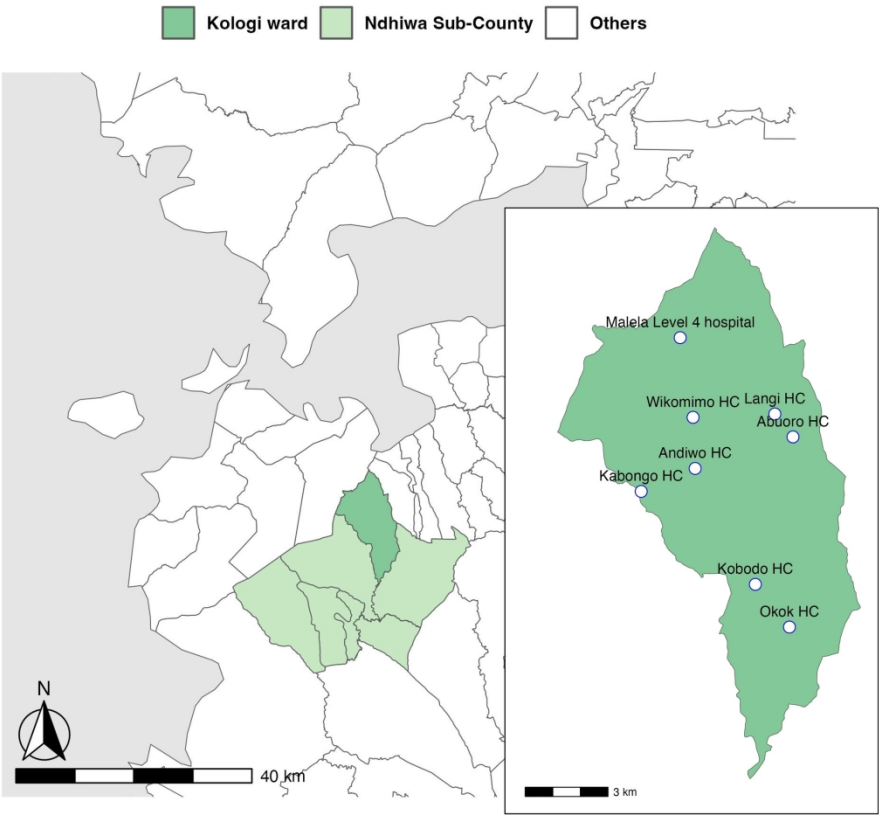
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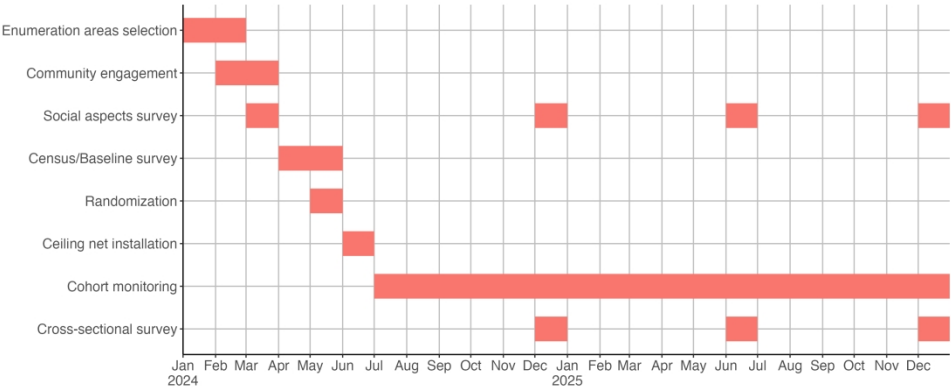
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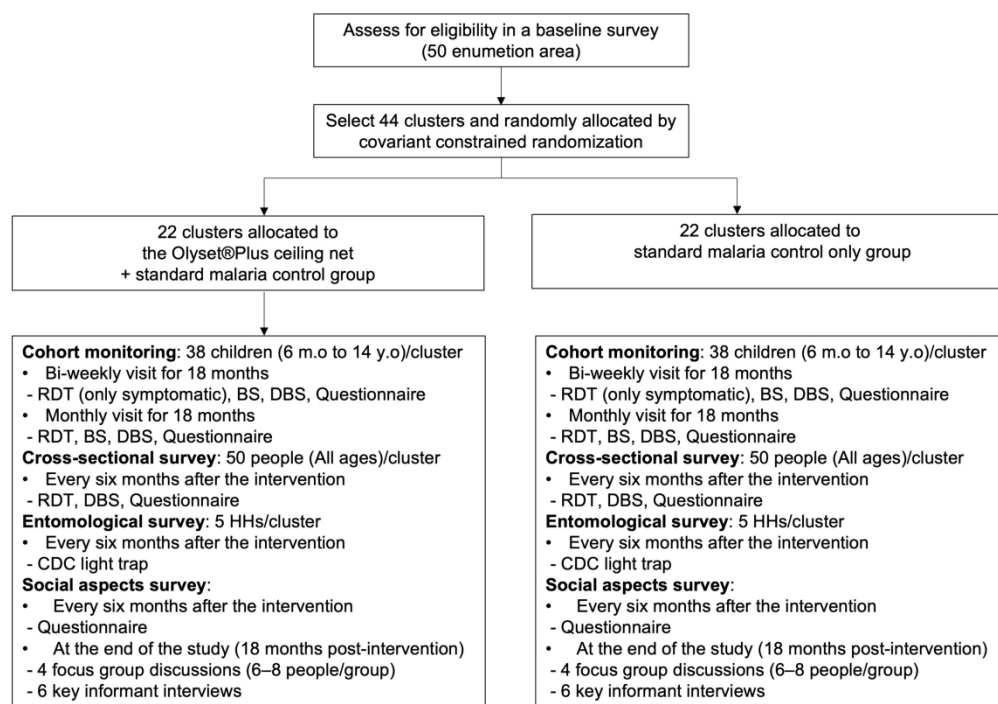


Map of the study area. Inset shows the locations of the level four hospital and seven health centers (HC) in Kanyamwa Kologi Ward.

216x179mm (300 x 300 DPI)



The schedule of trial activities.
774x322mm (118 x 118 DPI)



CONSORT flow diagram and the detail of each survey.

254x178mm (300 x 300 DPI)

Evaluation of the protective efficacy of Olyset®Plus ceiling nets for reduction of malaria incidence children in Homa Bay County, Kenya: statistical analysis plan for clinical and epidemiological outcomes

SAP version

Version 4.0

Apr 9, 2024 prepared by Yura K Ko (yongra.ko@ki.se)

SAP revisions

Version	Date	Summary of Changes
1.0	Jan 23, 2024	First draft
2.0	Feb 5, 2024	Added more details based on collaborators' feedback
3.0	Mar 4, 2024	Revised by the senior statistician (Dr. Daisuke Yoneoka)
4.0	April 9, 2024	Revised based on collaborators' feedback

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Introduction

Objectives

Primary objective:

- To determine the protective efficacy of Olyset®Plus ceiling nets in reducing malaria case incidence in children 6 months-14 years for 18 months post-intervention

Secondary objectives:

1. To determine the protective efficacy of Olyset®Plus ceiling nets in reducing malaria infection prevalence in all age groups at 6-, 12-, and 18-months post-intervention
2. To determine the protective efficacy of Olyset®Plus ceiling nets against the time to first malaria infection for 18 months post-intervention
3. To determine the spillover effects of Olyset®Plus ceiling nets in reducing malaria infection prevalence in all age groups at 6-, 12-, and 18-months post-intervention
4. To determine the protective efficacy of Olyset®Plus ceiling net in reducing *Plasmodium* infection incidence in children 6 months to 14 years old over 18 months post-intervention.

Study Methods

Trial design

The study is a cluster-randomized controlled trial (CRCT) with 44 clusters evenly divided between the intervention and the control arms. Each cluster will be one or two villages consisting of at least 50 households. A baseline survey will be conducted to determine pre-intervention *Plasmodium* prevalence and to collect demographic and socioeconomic data for covariate-constrained randomization of clusters. The baseline survey will be conducted approximately one month before randomization. The post-intervention follow-up period will be 18 months. Thirty-eight children aged 6 months to 14 years from each cluster will be recruited and followed for 18 months as a cohort to determine the protective efficacy of the Olyset®Plus ceiling net on clinical malaria incidence (primary objective), time to first *Plasmodium* infection, and *Plasmodium* infection incidence (secondary objectives). Cross-sectional surveys will be conducted at 6, 12, and 18 months post-intervention targeting 50 individuals of all ages from each cluster to determine the overall *Plasmodium* prevalence and to estimate the spillover effect (secondary objectives).

Randomization

After the baseline survey, covariate-constrained randomization will be used to allocate the 44 clusters across the two study arms. Covariate-constrained allocation ensures that the arms are balanced overall by excluding allocations where predetermined factors are not balanced within set margins. The following factors will be constrained: baseline malaria infection prevalence by RDT in children aged 0.5–14 years, LLIN usage, malaria vaccine coverage, socioeconomic status (SES), population size, the proportion of eligible houses for the ceiling net installation, and vector densities.

For the proportions of interest, we require the average difference between the arms of no more than 10% for the means of interest, and we require the difference in means to be no more than a quarter of the standard deviation of the variable among individuals in the population. After enumerating the allocations that fulfil the criteria, we may relax or tighten up the balance criteria when the allocated number is too small or very large. One allocation will be selected randomly among all possible allocations meeting the balancing constraints. Data on any additional potentially confounding ecological factors not included in the covariate-constrained randomization will be collected and adjusted for in the analysis. An independent statistician will perform the randomization.

Sample size

The sample size was calculated using the method of Hayes and Moulton¹. All the sample sizes will be recalculated based on the baseline data, which will be collected before the ceiling net installation.

The following calculations were based on the historical data collected from the same Lake Victoria region in Kenya with a clinical malaria incidence rate of 0.5 per person-year for children under 14 years old by RDT (personal communication), 40% parasite prevalence for all age groups by PCR, and a between-cluster coefficient of variation (CV) of incidence rate = 0.24 in both arms. In the study site, RTS, S vaccination began in 2019, with an additional mass distribution of pyrethroid-PBO LLINs at the end of 2023. Therefore, the intervention effect is expected to be smaller than in previous studies and was conservatively assumed to be 25%. Assuming 38 individuals per cluster to be followed for up to 18 months with 20 % loss-to-follow up rate, we require 22 clusters per arm to achieve 80% power to detect a significant incidence rate ratio of 0.75 (25% protective efficacy) at a two-sided type 1 error of 5%. With 44 clusters and 50 individuals per cluster, for the outcome of *Plasmodium* prevalence by PCR, we would achieve 80% power to detect a 23.5 % relative reduction. We do not specify the sample size for identifying spillover effects because spillovers tend to have smaller effect sizes relative to total or overall effects, so typically larger sample sizes are required to detect them. Although our study may be underpowered to detect spillovers, we will report the results as an exploratory analysis.

Framework

Our null hypothesis for the primary outcome is that Olyset®Plus ceiling nets + standard malaria treatment and prevention measures do not reduce the clinical malaria incidence compared to standard malaria treatment and prevention measures in children 6 months to 14 years at 18 months post-intervention.

Statistical interim analyses and stopping guidance

Neither the ceiling nets nor synergist PBO are known to pose significant health and safety risks. This has also been demonstrated in our previous CRT on Mfangano Island². Therefore, no interim analysis is planned.

Timing of final analysis

We will conduct the final analysis after 18 months of follow-up. Results will immediately be submitted for publication in peer-reviewed journals.

Timing of outcome assessments

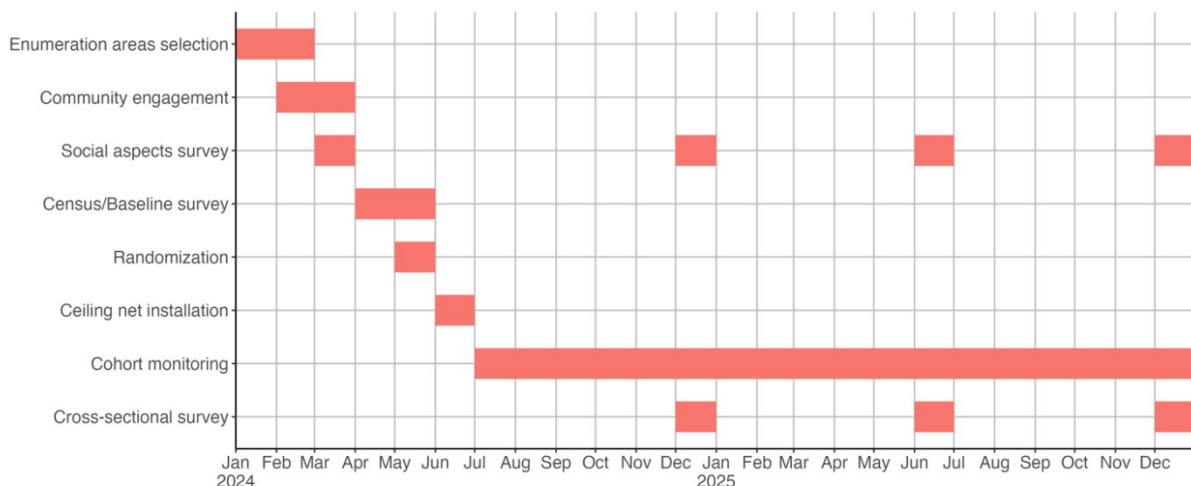


Figure1: Timetable of trial activities

Statistical Principles

Confidence intervals and P values

We will use a two-sided significance level of $\alpha = 0.05$ for hypothesis testing. All statistical tests will be conducted at this predetermined level of significance unless otherwise specified. For each estimated parameter, 95% confidence intervals will be calculated and reported.

Adherence and protocol deviations

Since the intervention (ceiling net) will be installed in trial participants' houses, participants not sleeping in their own houses will not benefit from the intervention. In the cohort, non-adherence to the intervention can be inferred from travel history during bi-weekly interviews. Therefore, participants who regularly sleep outside their homes will be removed from the analyses. In addition, if a cohort participant is absent for three consecutive visits or for more than half of all visits, the child will be excluded from the analysis. Other protocol deviations will be carefully documented and categorized during the study.

Analysis populations

The intention to treat (ITT) analysis is the primary analysis approach for both the primary and secondary objectives. The per-protocol (PP) analysis is included as a supplementary analysis for the primary and secondary objectives.

Trial population

Screening data

Screening data will be collected during the cohort enrollment and each cross-sectional survey to assess the eligibility of potential participants. This information will include demographic characteristics such as age, sex, SES, and other relevant parameters outlined in the study protocol.

Eligibility

The inclusion criteria for the installation of the Olyset®Plus ceiling net are (1) residential structures housing at least one permanent resident aged 18 years or older in the household, (2) informed consent provided by at least one adult in the household and (3) applicable house structure for the ceiling net in terms of size of the structure, presence of eave, ceiling board, and vertical beams, and material of the top part of the wall. The applicability of the ceiling net installation will be assessed by experienced field staff. The exclusion criteria are (1) vacant dwelling structure (confirmed by at least two visits by CHPs), (2) dwelling structure to be vacated or destroyed within the study period and (3) not applicable house structure for the ceiling net installation.

The inclusion criteria for prospective cohorts of children aged 6 months to 14 years old are (1) living in the study area at the time of Olyset®Plus ceiling net installation, (2) having no plan to leave or stay outside the study area for an extended period (longer than 1 month) over the 18-month follow-up period, and (3) informed consent provided by the participant's parent or guardian. The exclusion criterion is having severe chronic illnesses.

The inclusion criteria for cross-sectional malaria surveys for all age groups are (1) living in the study area during the study period, and (2) informed consent being provided by the parent or legal guardian before each survey. The exclusion criterion is having severe chronic illnesses.

Recruitment

For the baseline survey, we will randomly choose 50 enumeration areas (comprising one or two villages) in Kanyamwa Kologi Ward, Ndhiwa Sub-County. The survey includes a questionnaire for all households, mRDT testing of all children aged 6 months to 14 years. We will not create buffer zones to minimize contamination since a buffer zone of 400–600 m from the boundary will greatly reduce the number of houses in the core area available for analysis in many clusters. Thirty-eight eligible children will be randomly recruited into our cohort in each cluster. Recruitment will be limited to children aged 12 or younger, to prevent children from aging out during the 18 months monitoring period. For the cross-sectional survey at each time point, we will randomly select 50 individuals of all age groups from each

cluster. To reflect the age structure of the populations, the selection will be done with age category stratifications.

Withdrawal/follow-up

Those who migrate between the arms or emigrate from the study areas, or those who dismount the ceiling net from their house structure will be dropped from the intervention. For the cohort, those who are absent for three consecutive visits or for more than half of all visits will be excluded from the analysis as lost to follow-up. A summary of study participant selection is shown in Figure 2.

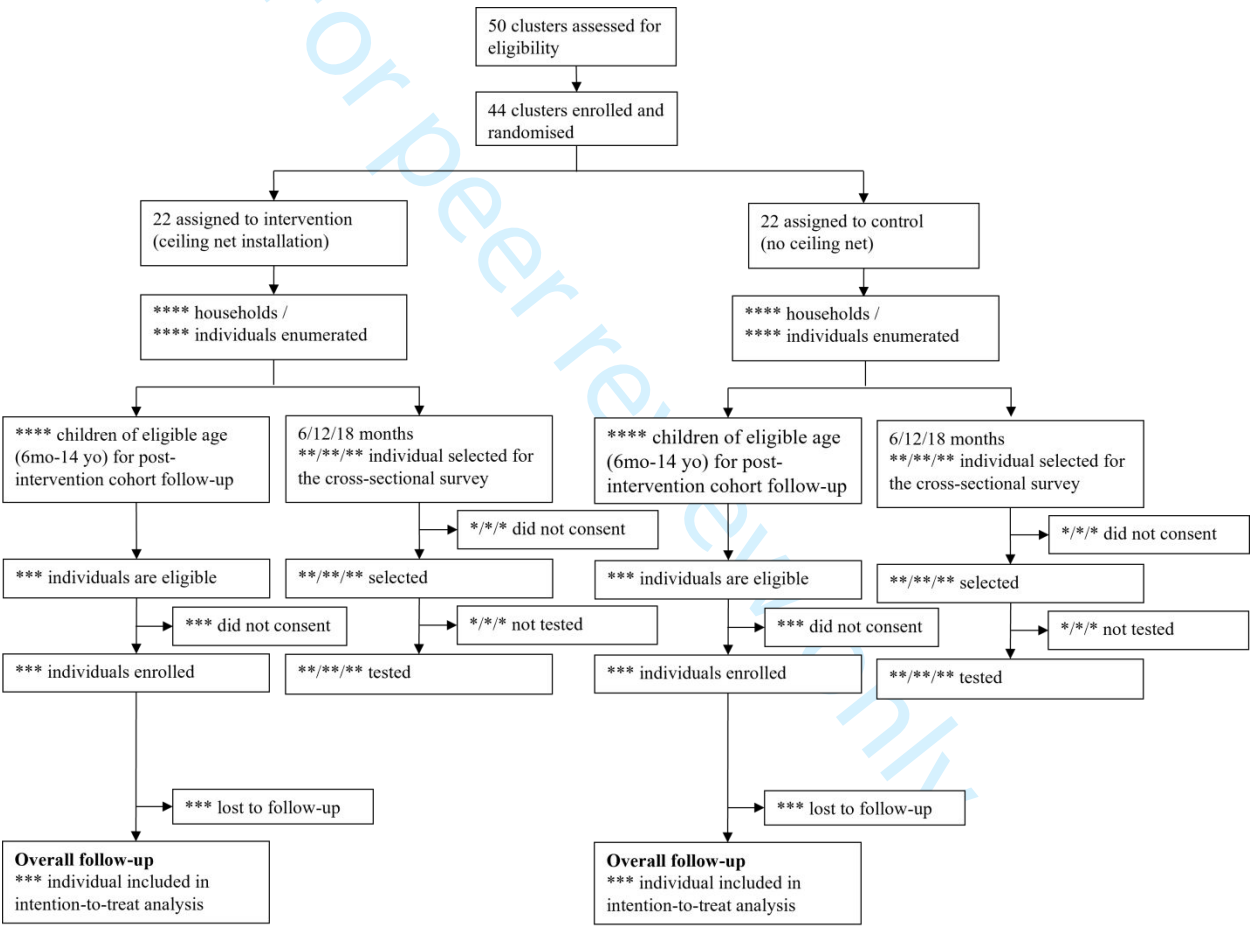


Figure 2: A schematic flow diagram of cluster allocation and study participant selection.

Baseline characteristics

We will report a list of baseline characteristics of the intervention and control arms. The list will include population, mean number of people per household, median age of population, number of selected children

for the cohort monitoring, number of selected individuals for each cross-sectional survey, malaria infection prevalence by RDT in children aged 0.5–14 years, LLIN usage, malaria vaccine coverage among children, SES, the proportion of suitable houses for the ceiling net installation, the mean indoor vectors per household per night.

Analysis

Endpoints

Primary endpoint:

- Overall malaria case incidence in children 6 months-14 years among intervention and control clusters during the 18-month follow-up period.

Secondary endpoints:

1. Malaria infection prevalence at 6, 12, and 18 months post-intervention in all age groups among intervention and control clusters.
2. Time to first malaria infections in children 6 months-14 years among intervention and control clusters during the 18-month follow-up period.

Definition of malaria case incidence

Incidence of clinical malaria in the prospective cohort will be estimated by both active and passive case detections. For active case detection, we will visit the home of cohort participants every two weeks. At each biweekly visit, axillary temperature will be taken from each cohort participant. If the participant has fever ($>37.5^{\circ}\text{C}$) or any malaria-related symptoms during or within 48 hours of the home visit, the child will be tested by mRDT. A clinical case is defined as positive mRDT accompanied by fever and/or any malaria-related symptoms and will be treated with artemether-lumefantrine (artemisinin-based combination therapy [ACT]). For passive case detection, we ask all cohort participants to visit designated health facilities in case they suspect malaria between home visits.

If two consecutive RDTs are positive, there are two patterns: active case detection or passive case detection for the detection of the second positive. If the second positive RDT is detected by active case detection, we will refer the child to a health facility and regard it as a new malaria infection if subsequent microscopy or PCR confirms parasites after 15 days or more passed from the first RDT test. If not, it is considered a carryover from the previous infection. For the passive case detection of a second RDT positive, we will regard it as a new malaria infection if more than 14 days have passed since the first RDT test.

For the overall incidence rate calculation, the time at the risk will be adjusted by subtracting the 14 days of “protection period” of ACT. If a participant misses a particular visit or a second positive is considered a carryover from the previous infection, the period is not included in the at-risk period.

If the cohort children visit health care facility and get tested for malaria between each visit, both positive and negative results will be utilized for our analysis. Specifically, the 14 days prior to the test result will be incorporated into the denominator of the incidence calculation as the at-risk period. Specific patterns for incidence rate calculation are shown in Figure 3.

If a participant is absent for three consecutive visits or for more than half of all visits, the child will be excluded from the analysis.

Definition of malaria infection incidence

In addition, we will test all cohort children by RDT and PCR every month. For the secondary outcome of time to first malaria infection and infection incidence, because our focus is only on infection, not symptomatic infection. We therefore use passive case detection differently to the above. If the cohort children visit health care facility because of any symptom and get negative RDT results for malaria, this data point is removed as it does not provide any additional information. If the RDT results in the facility is positive, the passive positive is assigned to either the active visit immediately before or after the passive case detection, whichever is closer in time to the passive case detection.

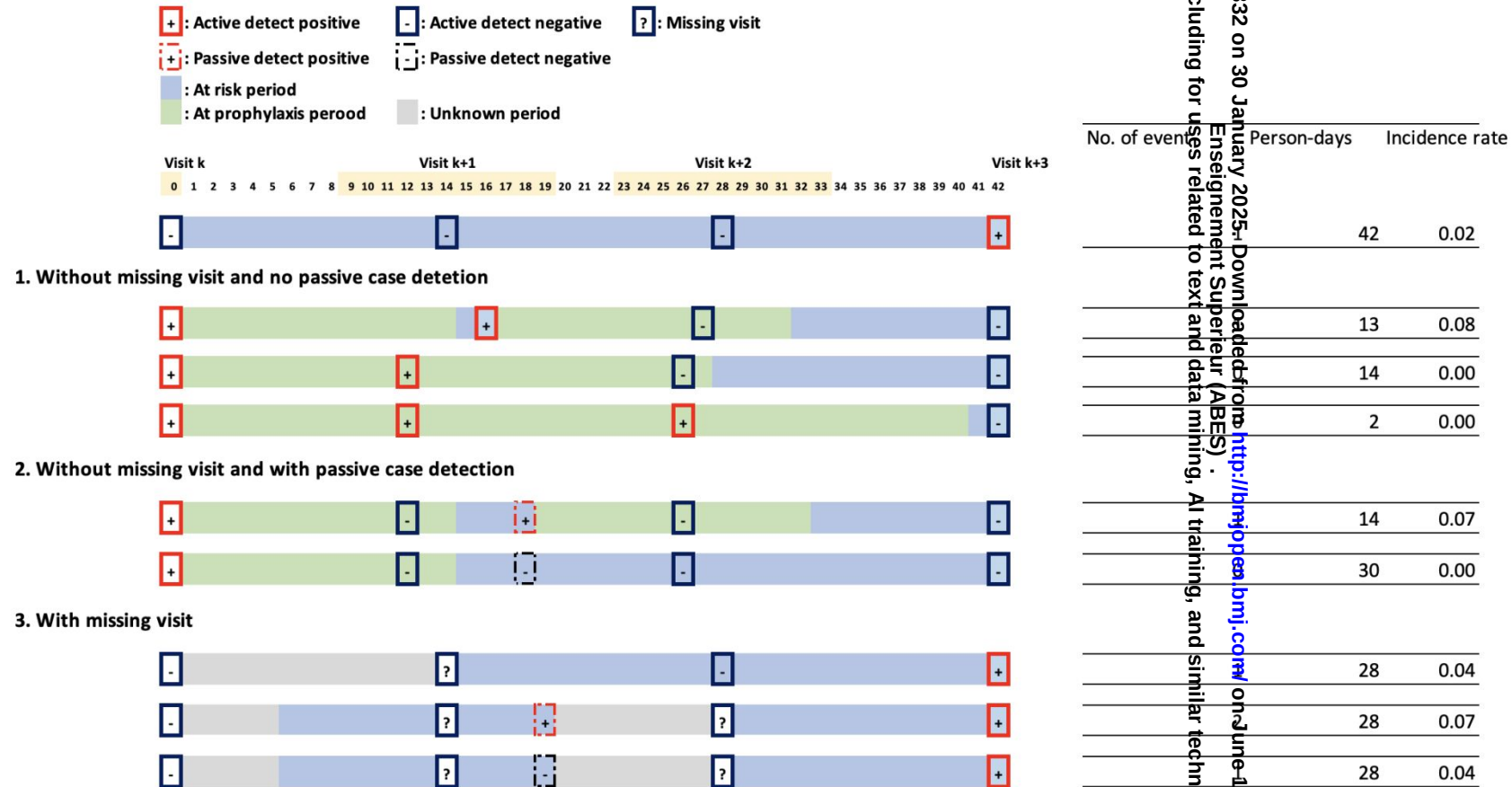


Figure 3: Specific patterns for incidence rate calculation.

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Analysis methods

We will follow the CONSORT guidelines extended for CRT³ for the statistical analysis and results reporting.

Clinical malaria incidence

We will determine the protective efficacy of Olyset®Plus ceiling nets against malaria case incidence by comparing clinical malaria incidence rates between arms. We will use mixed effects negative binomial regression accounting for within-cluster correlation of responses by following equations:

$$\mu_{k,i} = \exp(\beta_0 + \mathbf{x}_{k,i}^T \boldsymbol{\beta} + z_k),$$
$$z_k \sim N(0, \sigma^2),$$

where $\mu_{k,i}$ is the mean incidence rate of individual i in cluster k , $\mathbf{x}_{k,i}$ is the covariate vector including individual and cluster level data, z_k is the Gaussian-type random effect at the cluster level. The protective efficacy will be estimated by $(1 - \exp(\hat{\beta})) \times 100\%$, where $\hat{\beta}$ is the estimated regression coefficient of the treatment. Possible confounding factors such as age, sex, bed net usage, house structure, and SES will be adjusted as well as the covariates used in the covariate-constrained randomization. In addition, because we will not set a buffer zone, the distance to the nearest household in the other arm will be adjusted as a covariate to reduce the contamination between two arms. The variable was selected from the previous study⁴.

Prevalence of malaria infection

The secondary outcome, prevalence of malaria infection by PCR and microscopy measured at 6-, 12-, and 18-months after the ceiling net installation will be analyzed using mixed effects logistic regression adjusting for the above-mentioned confounding factors.

Time to first malaria infection

A Cox proportional hazards model and other survival models will be used to compare time to first malaria infection between arms adjusting for the above-mentioned confounding factors. In addition, we will account within-cluster correlation of responses.

Exploratory analysis for spillover effects

Evidence for positive spillover effects of the ceiling net on malaria infection prevalence of all age group will be assessed by comparing individuals with no intervention conditioning 1) the distance to ceiling net installed household, and 2) the coverage of surrounding households with ceiling net within 400 m (Figure 4). The distance of 400 m was chosen as the spillover effect appears to attenuate at this distance based on previous reports⁵. As there may be a bias that households without a ceiling net in the intervention cluster have different characteristics (e.g. preventive behaviour against malaria), we will include only control clusters for the spillover analysis to ensure comparability.

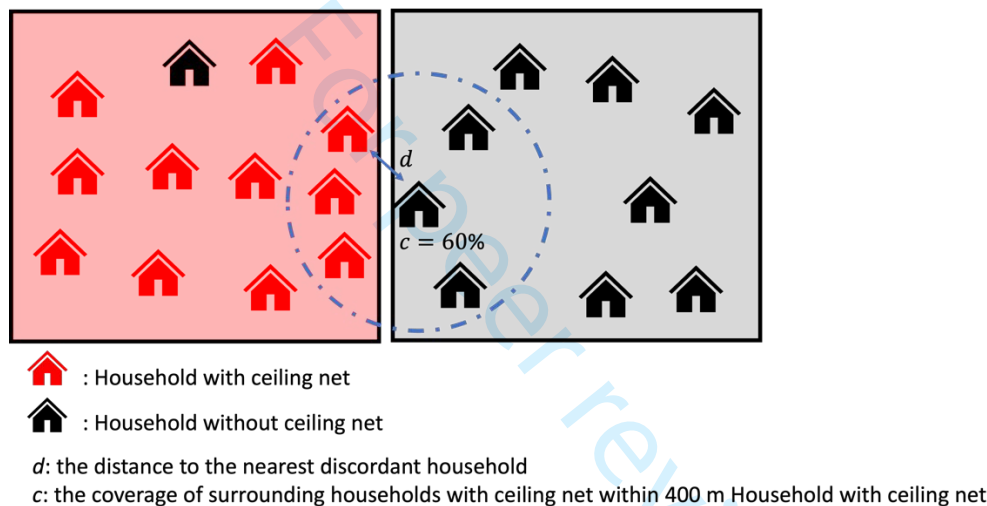


Figure 4: The distance to the nearest discordant household and the coverage of treatment.

Missing data

We will make substantial effort to avoid having missing values on outcome (malaria infection status and visit dates) by encouraging individual participants and CHPs repeatedly. When missing values occur for an outcome for reasons not related to the outcome, reasons for missingness and the missing fraction by treatment arm and cluster will be reported. Per protocol, the subjects are screened actively on their malaria status (the outcome) every four weeks.

In both cases, all the available data from the subject will be included in the primary and secondary analysis, without employing any specific missing data analysis techniques, due to the ignorability of the missing mechanisms. Missing baseline covariates (individual-level, household-level, and cluster-level) that are a part of the regression models for the outcome of interest will be imputed using simple hot-deck imputation methods if the missing fraction for the covariate is <5%. If the missing fraction for a covariable is ≥5%, appropriate multiple imputation approaches will be applied. If a non-ignorable portion

of the subjects have missing values on a covariate (due to missing at random or missing completely at random), that covariate may be excluded in the model.

Additional analysis

We will perform the same analysis for three age subgroups (≤ 59 months old; 5 years old to 14 years old; 15 years old or older) to examine if the effects of Olyset®Plus ceiling net differ by age groups. In addition, we will perform other machine learning based approach such as causal forest and super learner to estimate the conditional average treatment effect.

Harms

Since the chance of having adverse event due to this intervention is very low based on the preceding study, all the details of unanticipated problems will be narratively reported, if any.

Statistical software

For all data handling and analysis, we will use R software version 4.3.2 (R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.)

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BMJ Open

Evaluation of the protective efficacy of Olyset®Plus ceiling nets for reduction of malaria incidence in children in Homa Bay County, Kenya: a cluster-randomized controlled study protocol

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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Infectious diseases, Public health
Keywords:	Malaria, Mosquito Vectors, Infection control < INFECTIOUS DISEASES



Title

Evaluation of the protective efficacy of Olyset®Plus ceiling nets for reduction of malaria incidence in children in Homa Bay County, Kenya: a cluster-randomized controlled study protocol

Authors

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Abstract

Introduction: Malaria is still a major health problem in sub-Saharan Africa, where 98% of global malaria mortality occurs. In addition, the spread of *Plasmodium falciparum* with partial artemisinin resistance in East Africa and beyond is a great concern. The establishment of more effective vector control, in addition to the current long-lasting insecticide-treated net (LLIN) distribution program, is an urgent task in these areas. One novel vector control candidate is the pyrethroid-PBO ceiling nets (Olyset®Plus ceiling nets) which can overcome the problems of variations in net use behaviors and metabolic resistance to insecticide in vectors. Our preliminary study suggests the protective efficacy and high acceptability of this tool. With this proposed second trial, we aim to evaluate the impact of this tool in a different eco-epidemiological setting in the lake endemic region of Kenya.

Methods: A cluster randomized controlled trial is designed to evaluate the impact of pyrethroid-PBO ceiling nets in Ndhiwa Sub-County, Homa Bay County, Kenya. A total of 44 clusters will be randomly assigned in a 1:1 ratio to the intervention group (pyrethroid-PBO ceiling nets) and the control group. The assignment will be accomplished through covariate-constrained randomization of clusters. For the primary outcome of clinical malaria incidence, 38 children from each cluster will be enrolled in a cohort and followed for 18 months. We will also evaluate the effects of the intervention on entomological indicators as well as its acceptance by communities and cost-effectiveness.

Ethics and dissemination: Ethics approvals were provided by the Mount Kenya University Institutional Scientific Ethics Review Committee and the Ethics Committee Osaka Metropolitan University. Study results will be shared with study participants and communities, the Homa Bay County Government and the Kenya National Malaria Control Programme. Results will also be disseminated through publications, conferences and workshops to help the development of novel malaria control strategies in other malaria-endemic countries.

Trial registration: UMIN000053873

Keywords

Malaria, *Anopheles* mosquito, vector control, Pyrethroid resistance, Ceiling net, Kenya, Cluster-randomized controlled trial

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Administrative information

Title {1}	Evaluation of the protective efficacy of Olyset®Plus ceiling net on reducing malaria incidence in children in the Great Lake Region, Kenya: study protocol for a cluster-randomized controlled trial
Trial registration {2a and 2b}.	UMIN000053873
Protocol version {3}	Version 6.0
Funding {4}	This work is supported by the Japan International Cooperation Agency (JICA) and Japan Agency for Medical Research and Development (AMED) under the Science and Technology Research Partnership for Sustainable Development Goals (SATREPS) program.
Author details {5a}	Osaka Metropolitan University, Japan Nagasaki University, Japan Tohoku University, Japan National Institute of Infectious Diseases, Japan Mount Kenya University, Kenya National Malaria Control Programme, Nairobi, Kenya Kenya National Bureau of Statistics, Nairobi, Kenya Kenya Medical Research Institute, Kenya Homa Bay County, Kenya Karolinska Institutet, Sweden

	Stockholm University, Sweden
Name and contact information for the trial sponsor {5b}	Department of Virology and Parasitology/Research Center for Infectious Diseases, Graduate School of Medicine, Osaka Metropolitan University (OMU), Japan 1-4-3, Asahimachi, Abeno, Osaka, Osaka, Japan, 545-8585 TEL: + 81-6-6645-3760 Website: https://ocuparasitology.com/en/ Directorate of Research and Innovation, Mount Kenya University (MKU), Kenya General Kago Road, Thika, Kiambu, Kenya Website: https://www.mku.ac.ke
Role of sponsor {5c}	OMU will support project management oversight, trial management, data management, statistical analysis, and research governance. MKU also holds overall authority together with project management and analysis.

Strength and limitations of this study

- This is a second cluster-randomized controlled trial of a novel vector control tool, pyrethroid-PBO ceiling net, to evaluate its efficacy in reducing malaria incidence among children.
- The implementation of monthly active screening within the prospective cohort population established in each cluster facilitates the assessment of infection incidence.
- The incorporation of multidisciplinary outcomes, encompassing social aspects and cost-effectiveness analyses, provides valuable insights for the potential future deployment of this intervention within integrated malaria control strategies.
- One of the anticipated limitations is the possible contamination between intervention and control clusters because we will not set a buffer zone due to the geographical proximity among clusters.

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6 101 **Introduction**
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8 102 **Background and rationale {6a}**
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10 103 Malaria is still a major health problem, particularly in sub-Saharan Africa, where 98% of global malaria
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12 104 mortality occurs [1]. Although the morbidity and mortality of malaria declined from the 2000s to 2015
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14 105 owing to many investments and interventions, such as long-lasting insecticide-treated nets (LLINs), malaria
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16 106 rapid diagnostic tests (RDTs), and artemisinin-based combination therapies (ACTs), progress has stalled
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18 107 since 2015. Moreover, the spread of *Plasmodium falciparum* partially resistant to ACT in Africa is an
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20 108 enormous concern. Currently five African countries, Rwanda [2], Uganda [3], Eritrea [4], Ethiopia [5], and
21
22 109 the United Republic of Tanzania [6] have reported delayed clearance of *P. falciparum* after treatment with
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24 110 ACTs. Kenya’s proximity to these countries highlights the urgent need to establish effective vector control,
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26 111 in addition to maintaining antimalarial drug efficacy and strengthening resistance surveillance.
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31 113 Among several vector control measures, LLIN is the most widely adopted tool to prevent mosquito bites and
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33 114 interrupt malaria transmission. However, suboptimal uses of LLIN are one of the key factors in reducing the
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35 115 impact of LLIN on the malaria burden, together with insufficient provision in the mass net distribution
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37 116 program or shortening durability of nets [7]. In the Lake Victoria basin, alternative uses of LLIN for fishing
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39 117 and protecting crops and chicks are well-known local behaviors [8,9] as reported in other endemic areas [10].
40
41 118 In fact, in many areas including our study sites in Homa Bay County, Kenya, malaria prevalence remains
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43 119 high despite widespread distribution of LLINs and their periodic replacements for more than a decade. This
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45 120 suggests that LLIN alone is insufficient to interrupt malaria transmission in this region.
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50 122 Recently, we have proposed a novel vector control tool that covers the ceiling and the gap between the
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52 123 ceiling and the walls of residential structures with co-formulated pyrethroid and piperonyl butoxide (PBO)
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54 124 bed net material, called the Olyset®Plus (Sumitomo Chemical) ceiling net. The benefit of installing the
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56 125 pyrethroid-PBO ceiling net in addition to conventional LLINs is detailed elsewhere [11]. Briefly, the
57
58 126 pyrethroid-PBO ceiling net provides a combination of physical and chemical protection against mosquitoes
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60

which seek human bloodmeal in the house. Recent reports have demonstrated that a substantial proportion of residual biting exposure occurs between the hours of entering indoor spaces and retiring to bed [12], pyrethroid-PBO ceiling nets may have a significant impact. Furthermore, the ceiling net is semi-permanently installed and requires no further action from end users, thus its protective efficacy is consistently extended to all who stay in the house and less affected by factors such as discomfort or sleeping arrangement that contribute to variations in conventional LLIN use [13]. The concept of ceiling net was previously investigated [14], and in this study, by integrating it with pyrethroid-PBO bed net material, this tool is anticipated to be effective even against pyrethroid-resistant mosquitoes, which are widely reported across Africa.

The aim of this study is to evaluate the efficacy, acceptability, and cost-effectiveness of pyrethroid-PBO ceiling nets on malaria morbidity and transmission in the Lake Victoria basin of Kenya. Preliminary data from our previous study on Mfangano Island in Lake Victoria [11] suggest a substantial reduction in malaria prevalence among school children and high community acceptance of this tool (unpublished data). With this proposed second trial, we aim to evaluate the impact of this tool in a different eco-epidemiological setting with relatively higher malaria transmission, more frequent human and vector movement, and synergistic impact from other interventions such as indoor residual spraying (IRS) and the RTS,S malaria vaccine. Since effective malaria controls need to be tailored to the local context, evidence of the effectiveness of pyrethroid-PBO ceiling nets from various transmission settings will increase the appeal of this intervention. Furthermore, considering the recent increase in choices of malaria control tools and the necessity of combining various tools to maximize the impact of the malaria control program, it is important to understand the acceptability and cost-effectiveness of each intervention to guide its future deployment.

To achieve these objectives, our collaboration with local institutions including the Kenya National Bureau of Statistics (KNBS), the National Malaria Control Programme (NMCP), the Kenya Medical Research Institute (KEMRI), and Homa Bay County, started from the research planning stage. This collaboration is crucial to the seamless transition from field trial to expanded implementation and policy development.

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Objectives {7}

The study has four research domains: epidemiology, entomology, social aspects, and cost-effectiveness.

For the epidemiology domain, the primary objective is to determine the protective efficacy of pyrethroid-PBO ceiling net in reducing malaria clinical incidence in children 6 months to 14 years old over 18 months post-intervention. This age range was selected to include both children under five years who are at high risk of malaria-related morbidity and mortality, and the school-age children who have the highest prevalence of *Plasmodium* infections[15]. The secondary objectives are (1) to determine the protective efficacy of pyrethroid-PBO ceiling nets in reducing *Plasmodium* infection prevalence by PCR in all age groups at 6-, 12-, and 18- months post-intervention; (2) to determine the spillover effects of pyrethroid-PBO ceiling nets in reducing *Plasmodium* infection prevalence in all age groups at 6-, 12-, and 18-months post-intervention; and (3) to determine the protective efficacy of pyrethroid-PBO ceiling net in reducing *Plasmodium* infection incidence in children 6 months to 14 years old over 18 months post-intervention.

For the entomology domain, the primary objective is to evaluate the impact of pyrethroid-PBO ceiling nets on the indoor mosquito density of the primary malaria vector species captured by CDC light traps. The secondary objectives are (1) to determine the impact of pyrethroid-PBO ceiling nets on the entomological inoculation rate (EIR) and (2) to determine the prevalence of voltage gated sodium channel (VGSC) mutations in vectors.

For the social aspects domain, the primary objective is to assess the determinants of social acceptability of the pyrethroid-PBO ceiling net in both the intervention and control arms. The secondary objectives are (1) to determine the feasibility of installing the pyrethroid-PBO ceiling nets and (2) to measure attitudes, emotions, knowledge, and beliefs relating to the ceiling net in Ndhiwa Sub-County.

For the cost-effectiveness domain, the primary objective is to determine the incremental cost effectiveness ratios (ICERs) of adding the pyrethroid-PBO ceiling net to existing malaria control interventions under field

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trial conditions. The secondary objectives are (1) to establish the relative contribution to costs of the distinct programmatic elements and identify the inputs that contribute the most to overall costs, and (2) to estimate the potential cost of providing pyrethroid-PBO ceiling net at a larger scale over 3 and 5 years under operational scenarios.

Trial design {8}

The study is an open-label, cluster-randomized controlled trial (CRCT) with 44 clusters evenly divided between the intervention and the control arms. Each cluster will include one or two villages and consist of at least 50 households. A baseline survey will be conducted to determine the pre-intervention *Plasmodium* prevalence and *Anopheles* density, and to collect demographic and socioeconomic data for covariate-constrained randomization of clusters. The baseline survey will be conducted one month before cluster randomization. The post-intervention follow-up period will be 18 months. For the evaluation of the primary objective, 38 children aged 6 months to 14 years from each cluster will be recruited and followed for 18 months as a cohort. Cross-sectional surveys will be conducted after 6, 12, and 18 months of the intervention targeting 50 individuals of all ages from each cluster to estimate the overall *Plasmodium* prevalence.

Methods: Participants, interventions and outcomes

Study setting {9}

Location and administrative structure

Ndhiwa (713.5 km²) is one of nine sub-counties in Homa Bay County in Kenya. The sub-county has seven administrative wards: Kanyamwa Kologi, Kanyamwa Kosewa, Kabuoch North, Kwabwai, Kanyadoto, Kanikela, and Kabuoch South/Pala. Based on the number of malaria cases reported in the Kenya Health Information System (KHIS), the accessibility of the site, and population size, we selected Kanyamwa Kologi Ward as the target area (Figure 1). Agriculture is the primary economic activity, with sugarcane as a main commercial crop. County residents also keep animals such as dairy cattle, beef cattle, sheep, goats, and poultry [16]. The ward experiences a long rainy season from March to June and a short rainy season from October to December. As of 2019, the average monthly precipitation is 228.64 mm and the mean annual temperature is 26.7°C. The relative humidity remains elevated year-round, fluctuating between 75% to 85%

[17].

211

212 *Demographics*

213 The population of Kanyamwa Kologi Ward is approximately 33,000 according to the 2019 national census

214 [18]. The dominant ethnic group in the region is Luo and the primary languages are DhoLuo, Kiswahili, and

215 English. There are 172 primary and 36 secondary schools in Ndhiwa Sub-County [19]. Within Kanyamwa

216 Kologi Ward, there are 28 primary and 7 secondary schools.

217

218 *Malaria epidemiology and control measures*

219 Based on the KHIS, there were 429.1 and 457.2 confirmed malaria cases per 1,000 population in Ndhiwa

220 Sub-County and Kanyamwa Kologi Ward, respectively, in 2023. The primary malaria vector in the sub-

221 county is *Anopheles funestus*, which prefers feeding on humans. Although *An. arabiensis* exhibits

222 predominantly zoophilic behavior, it is also a significant malaria vector in our study area [20]. In Homa Bay

223 County, LLINs have been distributed every three years since the early 2000s, and IRS and the RTS,S malaria

224 vaccine have been piloted in several areas since 2018 and 2019, respectively [21]. Notably PBO-

225 incorporated LLINs (Veeralin®LN, manufactured by VKA Polymers, Tamil Nadu, India) were distributed in

226 late 2023. In Kanyamwa Kologi Ward, there is one level four hospital and seven health centers.

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228 **Eligibility criteria {10}**

229 As the ceiling nets are installed per structure, we set the inclusion criteria on a structural basis. The inclusion

230 criteria for the installation of the ceiling nets are (1) residential structures with at least one permanent

231 resident aged 18 years or older in the household, (2) informed consent provided by a resident in the

232 household, and (3) house structure amenable to ceiling net installation in terms of size of the structure,

233 presence of eave, ceiling board, and vertical beams, and material of the top part of the wall. The applicability

234 of the ceiling net installation will be assessed by experienced field staff. The exclusion criteria are (1) vacant

235 structure, confirmed by at least two visits by community health promoters (CHPs), (2) dwelling structure to

236 be vacated or destroyed within the study period, (3) non-eligible house structure for the ceiling net

237 installation, and (4) non-residential structures (school, shop, kitchen, storage, and toilet). The inclusion

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criteria for the prospective cohort are (1) children aged 6 months to 12 years old at the time of enrolment, (2) living in the study area at the time of pyrethroid-PBO ceiling net installation, (3) having no plan to leave or stay outside the study area for an extended period (longer than one month) over the 18-month follow-up period, and (4) informed consent provided by the participants or the parent or legal guardian. The exclusion criterion is having severe chronic illnesses. The inclusion criteria for cross-sectional malaria surveys for all age groups are (1) living in the study area during the study period, and (2) informed consent being provided by the participants or the parent or legal guardian before each survey. The exclusion criteria are (1) having severe chronic illnesses and (2) pregnancy known at the time of the surveys.

Who will take informed consent? {26a}

Written informed consent will be obtained by the study team members who fully understand the study protocol. After eligibility is confirmed, the study team members will present to the potential participant a document containing all relevant information about the study in Luo and English. If the participant cannot read, study information will be conveyed verbally in Luo, Kiswahili, and/or English by the study team members. The potential participant will have opportunities to ask any questions. Agreement to participate will be sought only after the participant indicates complete understanding of the study.

Additional consent provisions for collection and use of participant data and biological specimens {26b}

The study information document for ceiling net installation contains the study overview. In addition, the documents for cross-sectional and cohort surveys contain details on collecting, storing, and using personal data and biological specimens during the study.

Interventions

Explanation for the choice of comparators {6b}

In Kenya, LLIN is the most widely used malaria preventive measure. The Division of National Malaria Programme coordinates free LLIN distribution, and the county governments deliver LLINs to residents in all endemic counties every three years. In Homa Bay County, the RTS,S malaria vaccine has been implemented since 2019. The primary purpose of this trial is to demonstrate the superiority in malaria prevention of

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3 266 adding pyrethroid-PBO ceiling nets to the standard malaria control program. Thus, in the control arm, no
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5 267 pyrethroid-PBO ceiling nets will be installed, but LLIN use and RTS,S immunization will be allowed in the
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7 268 control and intervention arms as the current best practice. There is no plan for new LLIN distribution during
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10 269 the study period.

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14 271 **Intervention description {11a}**

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16 272 In the intervention arm, pyrethroid-PBO ceiling nets will be installed in all dwelling units where residents
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18 273 sleep, free of charge to the households. All participants will be encouraged to continue to use LLINs,
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20 274 distributed by the Homa Bay County government. In each intervention cluster, 1 CHP and 2 community
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22 275 volunteers will be recruited from the intervention cluster and another 1 CHP from the control cluster will
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24 276 join the team to enable future knowledge dissemination. The net installation team will be trained to install
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26 277 ceiling nets by skilled local research assistants who participated in previous trials. The head (or another
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28 278 adult) of the household eligible to a ceiling net will be notified at least 24 hours before the scheduled
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30 279 installation time. The cost of the ceiling nets and their installation will be covered by the research team.
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32 280 Details of the installation procedure are described in the previous study protocol [11]. Briefly, the ceiling net
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34 281 is a rectangular sheet of pyrethroid-PBO net with loops sewn along the diagonal seams. The loops are roped
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36 282 to the support beams under the roof and the edges of the net are stapled to the wall.
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41 284 **Criteria for discontinuing or modifying allocated interventions {11b}**

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43 285 As the ceiling net is semi-permanently installed, the intervention will only be discontinued if the participant
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45 286 specifically requests the removal of the ceiling net by the study team. There will be no crossover from the
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47 287 control arm to the intervention arm during the follow-up period. Those who migrate between the arms or
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49 288 emigrate from the study areas will be dropped from the study follow-up.
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54 290 **Strategies to improve adherence to interventions {11c}**

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56 291 Adherence to the intervention cohort in this study is defined as sleeping in houses with pyrethroid-PBO
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58 292 ceiling nets. Adherence is monitored indirectly by assessing the number of nights each participant spends
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60 293 outside their house during the monthly interview. During each house visit, CHPs will visually inspect the

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condition of the ceiling nets. Any visible tear and damage to the ceiling net will be reported to the research team, who will assess the size and location of the damage and perform repair or replace the ceiling net if necessary.

Relevant concomitant care permitted or prohibited during the trial {11d}

There is no specific concomitant care prohibited during the trial. All participants in both arms will continue to receive and use free LLIN and have access to standard medical care, including malaria testing by RDT, treatment with ACT and RTS,S malaria vaccination.

Provisions for post-trial care {30}

All participants will be under the normal healthcare system in the study setting. No perceived health risks for the intended population are expected with the intervention. To monitor the long-term impact of the intervention, the research team may conduct additional cross-sectional surveys 2 and 3 years post-intervention to monitor further parasite transmission in the population.

Outcomes {12}

Epidemiological domain: The primary outcome will be symptomatic malaria case incidence, defined as axillary temperature of $\geq 37.5^{\circ}\text{C}$ or a history of fever in the preceding 48 hours, and positive RDT, in children aged 6 months to 14 years enrolled in the cohort, monitored with a monthly visit and passive case detection in the health facilities during an 18-month follow-up. The secondary outcomes will be (1) the prevalence of *Plasmodium* infections by PCR in all age groups at 6, 12, and 18 months post-intervention, (2) the prevalence of *Plasmodium* infections by PCR among individuals without the ceiling net in all age groups at 6, 12, and 18 months post-intervention, and (3) infection incidence by PCR in the prospective cohort of children aged 6 months to 14 years over 18 months.

Entomological domain: The primary outcome will be the density of the primary malaria vectors, species composition and sporozoite infection rates. Indoor malaria vector density will be determined using CDC light trap, and species composition and sporozoite infection rates will be determined by microscopy and

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3 322 PCR. The secondary outcomes of the entomology domains will be (1) changes in EIR as a measure of
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5 323 malaria transmission and (2) prevalence of VGSC mutations associated with insecticide resistance in
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7 324 *Anopheles* mosquitoes captured by light trap.
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9 325
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11 326 Social aspect domain: The primary outcome will be the percentage of households consenting to pyrethroid-
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13 327 PBO ceiling net installation when offered. In addition, we will include observations and discussions about
14
15 328 individual attitudes toward the ceiling net. The secondary outcomes of the social aspect domain will be the
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17 329 percentage of the intact ceiling net, description of damaged net, and the impact on the living environment
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19 330 such as perceived temperature in the house, dirt/debris trapped by the ceiling net, loss of storage space at the
20
21 331 top of the wall, and rewiring of power lines. They will be evaluated by questionnaires at 6, 12, and 18
22
23 332 months post-intervention.
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25 333
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27 334 Cost-effectiveness domain: The primary outcome will be the incremental cost-effectiveness of adding
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29 335 pyrethroid-PBO ceiling net to existing malaria control interventions under field trial conditions from the
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31 336 societal and provider perspectives. The secondary outcomes of the cost-effectiveness domains will be (1) the
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33 337 costs of the distinct programmatic elements and the inputs that contribute the most to overall costs, and (2)
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35 338 the cost of providing pyrethroid-PBO ceiling net at a larger scale over three and five years under operational
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37 339 scenarios.
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41 341 **Participant timeline {13}**
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43 342 The schedule of trial activities is presented in Figure 2. The detail of each survey is described in Figure 3.
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45 343
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47 344 **Sample size {14}**
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49 345 The sample size was calculated using the method of Hayes and Moulton [22]. All sample sizes will be
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51 346 recalculated based on the baseline data, which will be collected about one month before the ceiling net
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53 347 installation.
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57 349 *Epidemiological survey*
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The following calculations were based on the historical data collected from the Lake Victoria region in Kenya with a clinical malaria incidence rate of 0.5 per person-year in children under 14 years old by RDT (unpublished data on Mfangano island), 40% parasite prevalence for all age groups by PCR and a between-cluster coefficient of variation (CV) in incidence rate of 0.24 in both groups. In the study site, RTS,S malaria vaccination began in 2019, with a mass distribution of PBO-incorporated LLINs at the end of 2023. Therefore, the intervention effect is expected to be smaller than those in previous studies and is conservatively assumed to be 25%. Assuming 38 individuals per cluster to be followed for up to 18 months with 20 % loss-to-follow up rate, we require 22 clusters per arm, a total of 1,672 children, to achieve 80% power to detect a significant incidence rate ratio of 0.75 (25% protective efficacy) at a two-sided type 1 error of 5%. With 50 individuals per cluster (2,200 total individuals) for the secondary outcome of *Plasmodium* prevalence by PCR in all age groups, we would achieve 5% type 1 error and 80% power to detect 23.5 % relative reduction. We do not specify the sample size for identifying spillover effects because spillovers tend to have smaller effect sizes relative to total or overall effects, so typically larger sample sizes are required to detect them. Although our study may be underpowered to detect spillovers, we will report the results as an exploratory analysis.

Entomological survey

Based on the previous entomological study conducted in Homa Bay County, we assume a mean vector density (number of mosquitoes per CDC light traps) of 3.3, a standard deviation (SD) of 3.3, and CV of 0.192 [14]. For 80% power to detect a 50% decrease in mean mosquito densities at 5% type 1 error level, we need to capture mosquitoes from five houses in each of 44 clusters.

Recruitment {15}

Thirty-eight eligible children in each cluster will be randomly recruited into our cohort. Recruitment will be limited to children aged 12 or younger, to avoid children aging out during the 18-month monitoring period. Study team staff will obtain informed consent from the parents or caregivers of the children before enrolling the children in the cohort. For the cross-sectional survey at each time point, we will randomly select from each cluster 50 individuals of all age groups. To guarantee the representativeness for all age groups, the

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selection will be done with following age category stratifications; 0-4, 5-9, 10-14, 15-19, and 20 and above.

Assignment of interventions: allocation

Sequence generation {16a}

Random numbers will be generated using the sample function in R software.

Concealment mechanism {16b}

The individual, household, and villages (clusters) are all given unique IDs at the beginning of the baseline.

Any following steps handle only these anonymized IDs.

Implementation {16c}

After the baseline survey, covariate-constrained randomization will be used to allocate the 44 clusters across the two study arms. The following factors will be constrained: baseline malaria infection prevalence by RDT in children aged 0.5–14 years, LLIN usage, malaria vaccine coverage, socioeconomic status (SES), population size, the proportion of eligible houses for the ceiling net installation, and vector densities. An independent statistician will perform the randomization. Local study assistants will perform participant enrollment.

Assignment of interventions: Blinding

Who will be blinded {17a}

Due to the visibility of the pyrethroid-PBO ceiling net, neither the trial participants nor the members of the study team who take part in field activities can be blinded. However, laboratory- and office-based personnel (e.g., microscopists, laboratory technicians, and data analysts) will be blinded to the identity and intervention status of the trial participants since all biological specimens will be identified by a unique numeric study identifier, and personal information will be removed before analyses.

Procedure for unblinding if needed {17b}

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This is an open-label trial, and only the data measurers are blinded. Therefore, there is no circumstance that they need to be unblinded.

Data collection and management

Questionnaires for the baseline survey, cohort surveys, and post-intervention cross-sectional surveys are provided in the supplementary file.

Plans for assessment and collection of outcomes {18a}

Census and baseline cross-sectional survey

In Kanyamwa Kologi Ward, 85 census enumeration areas (EAs) are defined by the 2019 Kenya Population and Housing Census. Births, deaths, and migrations in each EA are regularly updated by CHPs using the integrated community health system maintained by the Ministry of Health. Fifty EAs are randomly selected for our baseline survey, during which demographic information of all individuals is updated. To ensure balanced cluster allocation, the baseline survey includes a questionnaire for all households, RDT testing of all children aged 6 months to 14 years, and an entomological survey of randomly sampled households. We modified the questionnaire used in the 2020 Kenya Malaria Indicator Survey (KMIS) mainly to quantify the SES of each household and bed net usage. In addition, we add questions to quantify the favorability of ceiling nets before the intervention.

Cohort monitoring

Incidence of clinical malaria in the prospective cohort will be estimated by both active and passive case detections. For active case detection, we will conduct home visits every four weeks. From all cohort participants, axillary temperature will be measured using a digital thermometer, and *Plasmodium* infection status will be determined by RDT and PCR. Participants with fever ($>37.5^{\circ}\text{C}$) or other malaria-related symptoms listed in the Kenya National Malaria Treatment Guideline at the time of home visit or within the previous 48 hours will be tested for malaria by RDT. History of travel, confirmed malaria episode, and visit to local health facilities since the previous visit is recorded. For passive case detection, we ask all cohort participants to visit designated health facilities in case they suspect malaria between home visits. The

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2
3 433 designated facilities are asked to record all malaria tests performed regardless of their results together with
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5 434 the cohort ID. The cost of RDT and anti-malarial treatment will be covered by the research team to
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7 435 encourage cohort participants to use only designated facilities.
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11 437 *Cross-sectional malariometric surveys*
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13 438 Malaria prevalence in children and adults will be estimated using cross-sectional malariometric surveys in
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15 439 communities. These surveys will be conducted at 6, 12, and 18 months post-installation. Community surveys
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17 440 will be conducted by house visits.
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19 441 *Plasmodium* infection status will be determined using three methods: RDT, microscopy, and PCR. A finger-
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21 442 prick blood sample will be collected for on-site diagnosis using the Bioline Malaria Ag P.f/Pan RDT (Abbott
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23 443 Diagnostics Korea Inc., Republic of Korea). Survey participants with positive test results will be provided
24
25 444 with a treatment course of artemether-lumefantrine with dosing instructions in accordance with guidelines
26
27 445 from the Ministry of Health in Kenya after checking their recent treatment history. Blood smears will be
28
29 446 prepared on site and transported to the main laboratory in Homa Bay where thin smears are fixed with
30
31 447 methanol and all smears are stained with 3% Giemsa solution for 30 minutes, then examined by experienced
32
33 448 microscopists. Two blood samples (70 µl each) will be collected with a 75-mm heparinized micro-hematocrit
34
35 449 capillary tube (Thermo Fisher Scientific, MA, USA) and spotted on Whatman ET31 Chr filter paper
36
37 450 (Whatman International. Maidstone, UK). The blood samples will be allowed to dry at ambient temperature
38
39 451 and stored in individual zipped plastic bags at -20°C. The dried blood spots will be used for the determination
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41 452 of malaria status by PCR [23].
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43 453
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45 454 *Entomological surveys*
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47 455 Indoor mosquitoes will be collected from five randomly selected houses within each cluster using the CDC
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49 456 light trap method. Samples will be preserved in 96% ethanol and placed in a cool box with ice. Specimens
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51 457 will be examined for sex determination by microscopy and species identification by microscopy and PCR.
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53 458 Indoor mosquitoes will be collected at baseline, 6, 12 and 18 months post ceiling net installation.
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57 460 *Social aspects*
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We will conduct an exploratory sequential research design using integrated mixed methods (qualitative and quantitative). Qualitative assessment of community perceptions on the pyrethroid-PBO ceiling nets, community facilitators, and concerns of pyrethroid-PBO ceiling net use will be implemented, followed by quantitative assessments every 6 months and routine monitoring to evaluate the durability of pyrethroid-PBO ceiling nets using observation checklists in randomly sampled houses. At the end of the study, other qualitative case studies, such as focus group discussions and key informant interviews, will be conducted to document any remarks related to the study and inform the sustainability and scalability of the intervention.

Cost-effectiveness analysis

Incremental financial and economic cost data of pyrethroid-PBO ceiling net will be collected alongside the intervention. In cases where resources, such as staff, are shared among multiple elements, the allocation of costs will be carried out using an appropriate proxy. Costs related to research activities will be excluded from this allocation. Financial costs will be derived from project expenditure records, while economic costs, which encompass financial expenditures and donated resources, will be identified through project records and social aspects activities. The value of donated resources will be credited based on prevailing market rates. Furthermore, capital costs will be annualized over their useful life for financial costing and annualized at a discount rate of 3% for economic costing.

Plans to promote participant retention and complete follow-up {18b}

All surveys planned for the epidemiological and entomological domains will be conducted by house visits. CHPs will make an appointment with eligible participants before each visit to confirm the participants' available date and time. Small remunerations will be provided to survey participants to compensate for their time. CHPs will receive detailed instructions and participatory training for all field procedures and will be actively supervised by the research team throughout the duration of the study. Feedback will be regularly sought from CHPs regarding any issues raised by study participants, and discussions will be held to resolve issues from the field.

Data management {19}

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3 489 All data from the baseline, cohort, and cross-sectional surveys will be captured using the Research Electronic
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5 490 Data Capture (REDCap) software on electronic tablets. Data will be uploaded daily to a highly secure server
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7 491 hosted by Mount Kenya University (MKU). All data from the quantitative surveys will also be stored
8
9 492 securely and backed up regularly to prevent data loss. Data access and management of databases will be
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11 493 limited to authorized study investigators and collaborators. After validation of data uploaded to the MKU
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13 494 server, data stored locally on the tablet computers will be permanently deleted to minimize unauthorized
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15 495 access.

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20 497 **Confidentiality {27}**

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22 498 To maintain confidentiality, each participant in cross-sectional surveys, the longitudinal cohort, and the
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24 499 quantitative surveys is assigned a unique identifier. The data collected will be labelled using the unique
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26 500 identifier and stored separately from the key linking personal information (name, date of birth, GPS of each
27
28 501 household, and phone number). The data will be kept on a secure server that is only accessible to the
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30 502 research staff. Publications will contain only aggregated data, and no personal information will be included.

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35 504 **Plans for collection, laboratory evaluation and storage of biological specimens for genetic or molecular**
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37 505 **analysis in this trial/future use {33}**

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39 506 Anonymized blood samples from study participants will be stored and analyzed for *Plasmodium* infections
40
41 507 by microscopy and PCR in our laboratory in Homa Bay. Microscopic examinations of adult mosquito
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43 508 specimens will be conducted in our field laboratory in Mbita, while PCR analyses will be conducted in our
44
45 509 laboratories in Homa Bay and MKU. Laboratory data outputs will be entered in Microsoft Excel and
46
47 510 imported into the database. No human genetic analysis is planned for this study. However, remaining
48
49 511 biological materials will be stored indefinitely for future studies unless the participants opt out during the
50
51 512 informed consent process. Participants are provided with contact information of the research team and can
52
53 513 remove themselves from this study or any future studies at any time without penalty or prejudice.

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58 515 **Statistical methods**

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60 516 **Statistical methods for primary and secondary outcomes {20a}**

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We will follow the CONSORT guidelines extended for CRCT for statistical analysis and result reporting.

The intention-to-treat (ITT) analysis is the primary analysis approach for both the primary and secondary objectives for the epidemiological and entomological studies. The per-protocol (PP) analysis is included as a supplementary analysis for the primary and secondary objectives for the epidemiological and entomological studies. Detailed methodologies for the epidemiological part are described in the supplementary file of statistical analysis plan.

Clinical malaria incidence

We will determine the protective efficacy of pyrethroid-PBO ceiling nets against malaria case incidence by comparing clinical malaria incidence rates between arms. We will use mixed effects negative binomial regression accounting for within-cluster correlation of outcomes. Possible confounding factors such as age, sex, bed net usage, house structure, malaria vaccination history, and SES will be adjusted as well as covariates used in the covariate-constrained randomization. In addition, because we will not set a buffer zone, the distance to the nearest household in the other arm will be adjusted in the following analysis to reduce the contamination between two arms. The variable was selected from the previous study [24].

Prevalence of malaria infection

The secondary outcome, the prevalence of malaria infection by PCR and microscopy measured at 6, 12, and 18 months after the ceiling net installation will be analyzed using mixed effects logistic regression adjusting for the above-mentioned confounding factors.

Exploratory analysis for spillover effects

Evidence for positive spillover effects of the ceiling net on malaria infection prevalence in all age groups will be assessed by comparing individuals with no intervention conditioning 1) the distance to the nearest ceiling net installed household, and 2) the coverage of surrounding households with ceiling net within 400 m. The distance of 400 m was chosen as the spillover effect appears to attenuate at this distance based on previous reports [25].

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Entomology

Differences in vector density and EIR between arms will be evaluated by random effects negative binomial regression taking into account the intracluster correlation.

Social aspects

We will employ the Framework for Reporting Adaptations and Modifications to Evidence-based Implementation Strategies (FRAME-IS) [26] to document the implementation processes of the ceiling nets, and the evidence integration triangle framework [27] to align the evidence generated to policy and vector control strategies from the health systems aspect. The theoretical framework in qualitative research will be grounded theory [28]. Data from ethnographic, focus group discussions, key informant interview will be summarized using content thematic analysis. Pre- and post-intervention acceptability to install pyrethroid-PBO ceiling net intervention will be compared to actual consent using logistic regressions.

Cost-effectiveness

The economic and financial costs associated with the pyrethroid-PBO ceiling net intervention will be presented in total and disaggregated forms, highlighting the relative contribution of each program element to the overall program costs. To facilitate comparisons with other malaria vector control interventions, the costs will be converted into cost per household and per person receiving the intervention annually. Various program scenarios, such as different scales and durations, will be presented to estimate operational implementation costs. Compared to the control group, we will utilize the number of malaria cases averted in the pyrethroid-PBO ceiling net arm to calculate the DALYs averted using standard methods.

Interim analyses {21b}

No interim analysis is planned because neither the insecticide permethrin nor the synergist PBO as formulated in pyrethroid-PBO LLINs is known to pose significant health and safety risks [11,14].

Methods for additional analyses (e.g. subgroup analyses) {20b}

We will perform the same analysis for three age subgroups (≤ 59 months old; 5 years old to 14 years old; 15

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years old or older) to examine if the effects of pyrethroid-PBO ceiling net differ by age groups. In addition, we plan to use other machine learning methods to estimate the conditional average treatment effect (CATE), such as causal forests—which extend random forest algorithms for causal inference [29]—and the super learner algorithm, an ensemble method that combines multiple predictive models to improve accuracy [30].

Methods in analysis to handle protocol non-adherence and any statistical methods to handle missing data {20c}

In the cohort, non-adherence to the intervention can be identified by monthly interviews. Participants who regularly sleep outside their homes will be removed from the analyses. The extent and patterns of missing data will be assessed once all data collection has been completed. If necessary, we will apply simple hot-deck imputation methods if the missing fraction for the covariate is $<5\%$ or appropriate multiple imputation approaches if the missing fraction for a covariable are $\geq 5\%$. If a non-ignorable portion of the subjects have missing values on a covariate (due to missing at random or missing completely at random), that covariate may be excluded in the model.

Plans to give access to the full protocol, participant level-data and statistical code {31c}

This manuscript is the full protocol. The corresponding author will make the de-identified datasets or any future statistical code available upon reasonable request.

Oversight and monitoring

Composition of the coordinating centre and trial steering committee {5d}

The sampling team, composed of CHPs and laboratory technicians, set up a day-to-day communication group and exchanged their experiences. A local management team of study investigators from Kenya and Japan also joined this, leading and advising the activities and monitoring the sample and data integrity. A monthly meeting will be held by the steering committee composed of all key researchers from Kenya and Japan, including the principal investigator (PI) and co-PI, to monitor the progress of the trial.

Composition of the data monitoring committee, its role and reporting structure {21a}

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3 601 Our intervention is considered to be of a low-risk nature. The data safety monitoring committee will consist
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5 602 of two medical doctors who are independent from the project organizations and sponsor and have no
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7 603 competing interests. The primary responsibilities of this committee will be to periodically review self-
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9 604 reported adverse events derived from the monthly questionnaire in the cohort. All severe adverse events
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11 605 observed or reported during the study will be reported to the committee in a timely manner, and the
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13 606 committee will determine the relationship between the severe adverse events and the intervention. For
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15 607 additional credibility about study quality, the researchers will consult a third statistician, if necessary.
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20 609 **Adverse event reporting and harms {22}**

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22 610 In addition to the safety monitoring committee, researchers will compare self-reported non-serious adverse
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24 611 events such as coughs, rashes, and itches between the intervention and the control arms in the cohort and
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26 612 cross-sectional surveys. In the event of a study-related serious adverse event, the study team will convene a
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28 613 meeting immediately with the MOH and Homa Bay County Teaching and Referral Hospital representatives
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30 614 to review the case and take necessary action.
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35 616 **Frequency and plans for auditing trial conduct {23}**

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37 617 A monthly meeting will be held during the follow-up period to ensure that all surveys and investigations are
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39 618 conducted according to the study protocol. The study is required to submit annual reports and renewal to
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41 619 ethical review boards of Osaka Metropolitan University, Japan, and Mount Kenya University, Kenya.
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45 621 **Plans for communicating important protocol amendments to relevant parties (e.g. trial participants,**
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47 622 **ethical committees) {25}**

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49 623 Decisions on important trial amendments must be made through a formal procedure and will be approved by
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51 624 institutional review boards (IRB) at Mount Kenya University and Osaka Metropolitan University. The
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53 625 protocol in the clinical trials registry will also be updated accordingly.
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58 627 **Dissemination plans {31a}**

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60 628 Study results will be shared with the study participants and communities, the Homa Bay County Government

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and the Kenya National Malaria Control Programme. Results will also be disseminated through publications, conferences and workshops to help the development of novel malaria control strategies in other malaria-endemic countries. Suggestions from the participants will also help shape the future improvement of the intervention.

Discussion

Global malaria progress has flatlined in recent years: targets of reductions in malaria morbidity and mortality and required funding by 2030 are all off track as of 2023[6]. In addition, *P. falciparum* with partial artemisinin resistance, which has been a problem in the Great Mekong Subregion (GMS) for more than a decade, is emerging independently in sub-Saharan Africa [2–6,31]. Novel interventions that are cost-effective and widely accepted by local communities are urgently needed to contain the spread of artemisinin-resistant *P. falciparum* in sub-Saharan Africa.

Early results from our cluster randomized controlled trial of pyrethroid-PBO ceiling nets on Mfangano Island in Lake Victoria, Kenya suggest that ceiling nets can reduce *Plasmodium* prevalence and are positively received by the local communities. Nevertheless, there are regional differences in housing design, vector abundance and composition, and availability of malaria control interventions. As such the feasibility and acceptability of the ceiling net intervention are likely to depend on local eco-epidemiological context [32]. Furthermore, one of the secondary objectives in this study is to measure the spillover effects, i.e. how much a household that does not have a ceiling net benefits from living near a house with a ceiling net. This enables a broader understanding of the impact of the ceiling nets at the community level.

This trial has several limitations. First, although the study is designed as a cluster-randomized controlled trial, contamination between intervention and control clusters cannot be excluded, as buffer zones between intervention and control clusters cannot be created due to geographic proximity of houses and villages in the ward. A recent study, however, has shown that the spillover effect of interventions on malaria can extend to 3 km [33], so buffer zones of a few hundred meters, as set out in many studies, may not be sufficient. We will try to eliminate such contamination effects by integrating spatial data into our statistical model. Second,

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2
3 657 because of the visible nature of the ceiling net, we cannot exclude open-label and observer biases. It is
4
5 658 conceivable that participants receiving ceiling nets may reduce their usage of conventional LLIN, as both
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7 659 interventions are made of the same materials and may be perceived to protect against malaria in the same
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9 660 manner. We aim to reduce such bias as much as possible through repeated reminders by CHPs that ceiling
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11 661 nets serve as an addition to and not a replacement of conventional LLINs. We will conduct surveys and in-
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13 662 depth interviews to elicit participants' perceptions of the ceiling net, which can guide future messaging and
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15 663 implementation. To reduce observer bias, laboratory investigators and data analysts will be blinded. Third, in
16
17 664 the study area, pyrethroid+PBO-incorporated LLINs were distributed in 2023. It may reduce the effect of our
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19 665 ceiling net intervention because pyrethroid+PBO-incorporated LLINs are more effective than non-PBO-
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21 666 incorporated LLINs by targeting both *Anopheles* vectors with and without metabolic resistance to
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23 667 pyrethroids. Pyrethroid+PBO incorporated LLINs received a conditional endorsement from the World
24
25 668 Health Organization (WHO) in 2017, and approximately half of the LLINs distributed in sub-Saharan Africa
26
27 669 in 2022 were of this type [6]. Given the abundance of PBO-incorporated LLINs in the region, it is important
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29 670 to assess the effectiveness of the pyrethroid-PBO ceiling net as an addition to these LLINs to inform policy
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31 671 recommendations. Recently LLINs combining two different classes of insecticides have been shown to be
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33 672 superior to pyrethroid-based LLINs [34]. When these new LLINs become widely available, the effectiveness
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35 673 of pyrethroid-PBO ceiling nets needs to be re-investigated.
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41 675 **Trial status**

42
43 676 The Baseline survey was started on April 8, 2024. The recruitment of the intervention participants and the
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45 677 ceiling net installation were conducted in June 2024. The current protocol is version 6.0 as of November 11,
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47 678 2024.
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51 679
52 680 **Abbreviations**

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54 681 ACT: artemisinin-based combination therapy

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56 682 CHP: community health promoter

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58 683 CRCT: cluster-randomized controlled trial
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CV: coefficient of variation

KHIS: Kenya Health Information System

ITN: insecticide treated nets

IRS: indoor residual spraying

LLIN: long-lasting insecticidal nets

MKU: Mount Kenya University

PBO: piperonyl butoxide

RDT: rapid diagnosis tests

VGSC: Voltage gated sodium channel

Declarations

Acknowledgements

We would like to express our sincere gratitude to this study's participants, field, and laboratory staff. In addition, we acknowledge the collaboration and support of health offices in Homa Bay County, Kenya.

Authors' contributions {31b}

AK and JG are co-principal investigators. AK is the guarantor. YKK, WK, and AK developed the original concept. All authors discussed and contributed to the study protocol. YKK, WK, PO, KBM, JK, VO, JO, SMM, KNBS, KK, ES, GO, and AK contributed the preparation of the baseline survey. YKK, WK, PO, BM, TO, CWC, JK, SM, and MK drafted the manuscript. YKK, WK, CWC, MK, GO, and JG contributed to the revisions of the draft of the manuscript. DY participated as a senior statistician. YKK and MK drafted the statistical analysis plan (SAP) and WK, CWC, and DY revised. The authors read and approved the final manuscript and SAP.

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3 711 Chemical Corporation. The funding bodies play no role in the study design, data collection, analysis,
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5 712 interpretation, and publication.
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10 714 **Availability of data and materials {29}**

11 715 The study regimes, consent forms, assent forms, and study-related materials are accessible from the
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13
14 716 corresponding author. The final trial dataset will be available to all investigators. The corresponding author
15
16 717 will make the de-identified datasets and source codes for all analysis available upon reasonable request.
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20 719 **Patient and public involvement**

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22 720 Although the study design was developed through discussions among the researchers, consultations with the
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24 721 local population were conducted prior to initiating the baseline survey, and their input was incorporated into
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26 722 the study. Community involvement will also be ongoing during the implementation of interventions and
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28 723 research activities.
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33 725 **Ethics approval and consent to participate {24}**

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35 726 Ethics approvals were received from Mount Kenya University Institutional Scientific Ethics Review
36
37 727 Committee (MKU-ISERC) (approval number: 2565) and the Ethics Committee in Osaka Metropolitan
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39 728 University (approval number: 2024-068).
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41 729 Written informed consents will be sought from study participants before the baseline survey, installation of
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43 730 ceiling nets, each cross-sectional survey, and the start of prospective cohort surveys. In cross-sectional and
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45 731 cohort surveys, informed assent will be obtained from children under the age of 15 who can understand the
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47 732 study at a level appropriate for their development, in addition to the consent of a parent or legal guardian.
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49 733 Participants have the right to withdraw from the study at any time, and the option to withhold previously
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51 734 collected samples from any future analyses and studies.
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54 735 The samples collected in this study may potentially be used for other research purposes. This is clearly stated
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56 736 in the informed consent form. In such cases, we will obtain the necessary ethical approval and provide
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58 737 participants with the chance to opt-out from this. All experiments will be carried out in adherence to WHO
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60 738 requirements and the Declaration of Helsinki.

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Consent for publication {32}

We will not present identifying images or other personal or clinical details of participants. The participant information materials and informed consent form are available from the corresponding author on request.

Competing interests {28}

AK and JG were partially supported by a research grant from Sumitomo Chemical Corporation. Other authors had no competing interests.

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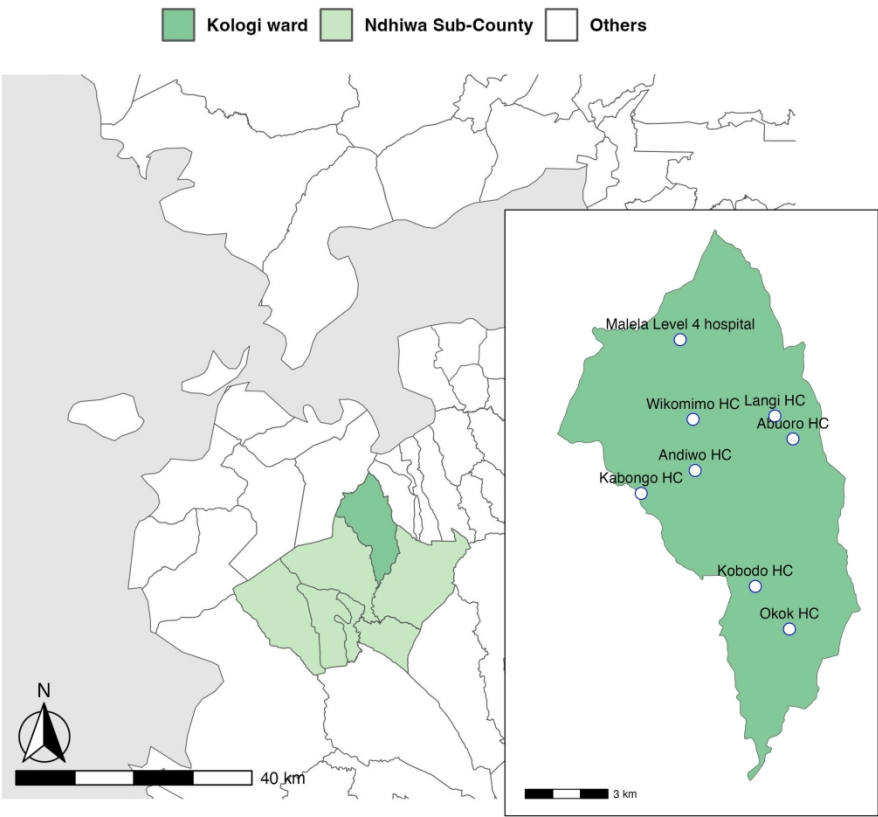
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Figure 1: Map of the study area. Inset shows the locations of the level four hospital and seven health centers (HC) in Kanyamwa Kologi Ward.

Figure 2: The schedule of trial activities.

Figure 3: CONSORT flow diagram and the detail of each survey



Map of the study area. Inset shows the locations of the level four hospital and seven health centers (HC) in Kanyamwa Kologi Ward.

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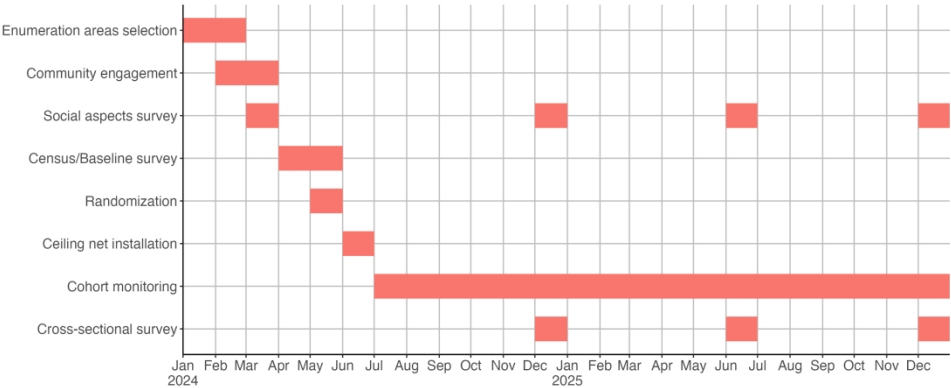
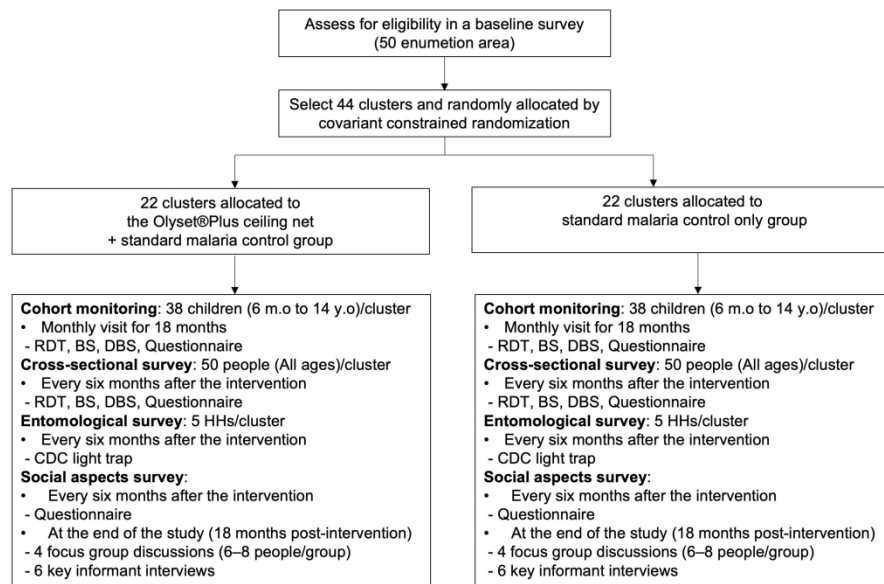


Figure 2: The schedule of trial activities.
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CONSORT flow diagram and the detail of each survey

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Evaluation of the protective efficacy of Olyset®Plus ceiling nets for reduction of malaria incidence children in Homa Bay County, Kenya: statistical analysis plan for clinical and epidemiological outcomes

Version 6.0

Nov 1, 2024 prepared by Yura K Ko (yongra.ko@ki.se)

SAP revisions

Version	Date	Summary of Changes
1.0	Jan 23, 2024	First draft
2.0	Feb 5, 2024	Added more details based on collaborators' feedback
3.0	Mar 4, 2024	Revised by the senior statistician (Dr. Daisuke Yoneoka)
4.0	April 9, 2024	Revised based on collaborators' feedback
5.0	Jun 4, 2024	Changed the cohort monitoring interval to one month due to feasibility after discussion with CHPs and local research staff.
6.0	Nov 1, 2024	1) Removed the secondary objective of time-to-first infection because it is impossible to ascertain the outcome without initial parasite clearance at enrollment. 2) Modified the definition of infection incidence based on the journal reviewer's comments.

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Introduction

Objectives

Primary objective:

- To determine the protective efficacy of **pyrethroid-PBO** (Olyset®Plus) ceiling nets in reducing malaria case incidence in children 6 months-14 years for 18 months post-intervention

Secondary objectives:

1. To determine the protective efficacy of **pyrethroid-PBO** ceiling nets in reducing malaria infection prevalence in all age groups at 6-, 12-, and 18-months post-intervention
2. To determine the spillover effects of **pyrethroid-PBO** ceiling nets in reducing malaria infection prevalence in all age groups at 6-, 12-, and 18-months post-intervention
3. To determine the protective efficacy of **pyrethroid-PBO** ceiling net in reducing malaria infection incidence in children 6 months to 14 years old over 18 months post-intervention.

Study Methods

Trial design

The study is a cluster-randomized controlled trial (CRCT) with 44 clusters evenly divided between the intervention and the control arms. Each cluster will be one or two villages consisting of at least 50 households. A baseline survey will be conducted to determine pre-intervention *Plasmodium* prevalence and to collect demographic and socioeconomic data for covariate-constrained randomization of clusters. The baseline survey will be conducted approximately one month before randomization. The post-intervention follow-up period will be 18 months. Thirty-eight children aged 6 months to 14 years from each cluster will be recruited and followed for 18 months as a cohort to determine the protective efficacy of the **pyrethroid-PBO** ceiling net on clinical malaria incidence (primary objective) and *Plasmodium* infection incidence (secondary objectives). Cross-sectional surveys will be conducted at 6, 12, and 18 months post-intervention targeting 50 individuals of all ages from each cluster to determine the overall *Plasmodium* prevalence and to estimate the spillover effect (secondary objectives).

Randomization

After the baseline survey, covariate-constrained randomization will be used to allocate the 44 clusters across the two study arms. Covariate-constrained allocation ensures that the arms are balanced overall by excluding allocations where predetermined factors are not balanced within set margins. The following factors will be constrained: baseline malaria infection prevalence by RDT in children aged 0.5–14 years, LLIN usage, malaria vaccine coverage, socioeconomic status (SES), population size, the proportion of eligible houses for the ceiling net installation, and vector densities. For the proportions of interest, we require the average difference between the arms of no more than 10% for the means of interest, and we require the difference in means to be no more than a quarter of the standard deviation of the variable among individuals in the population. After enumerating the allocations that fulfil the criteria, we may relax or tighten up the balance criteria when the allocated number is too small or very large. One allocation will be selected randomly among all possible allocations meeting the balancing constraints. Data on any additional potentially confounding ecological factors not included in the covariate-constrained randomization will be collected and adjusted for in the analysis. An independent statistician will perform the randomization.

Sample size

The sample size was calculated using the method of Hayes and Moulton¹. All sample sizes will be recalculated based on the baseline data, which will be collected before the ceiling net installation.

The following calculations were based on the historical data collected from the same Lake Victoria region in Kenya with a clinical malaria incidence rate of 0.5 per person-year for children under 14 years old by RDT (personal communication), 40% parasite prevalence for all age groups by PCR, and a between-cluster coefficient of variation (CV) of incidence rate = 0.24 in both arms. In the study site, RTS, S vaccination began in 2019, with an additional mass distribution of pyrethroid-PBO LLINs at the end of 2023. Therefore, the intervention effect is expected to be smaller than in previous studies and was conservatively assumed to be 25%. Assuming 38 individuals per cluster to be followed for up to 18 months with 20 % loss-to-follow up rate, we require 22 clusters per arm to achieve 80% power to detect a significant incidence rate ratio of 0.75 (25% protective efficacy) at a two-sided type 1 error of 5%. With 44 clusters and 50 individuals per cluster, for the outcome of *Plasmodium* prevalence by PCR, we would achieve 80% power to detect a 23.5 % relative reduction. We do not specify the sample size for identifying spillover effects because spillovers tend to have smaller effect sizes relative to total or overall effects, so typically larger sample sizes are required to detect them. Although our study may be underpowered to detect spillovers, we will report the results as an exploratory analysis.

Framework

Our null hypothesis for the primary outcome is that pyrethroid-PBO ceiling nets + standard malaria treatment and prevention measures do not reduce the clinical malaria incidence compared to standard malaria treatment and prevention measures in children 6 months to 14 years at 18 months post-intervention.

Statistical interim analyses and stopping guidance

Neither the ceiling nets nor synergist PBO are known to pose significant health and safety risks. This has also been demonstrated in our previous CRT on Mfangano Island². Therefore, no interim analysis is planned.

Timing of final analysis

We will conduct the final analysis after 18 months of follow-up. Results will immediately be submitted for publication in peer-reviewed journals.

Timing of outcome assessments

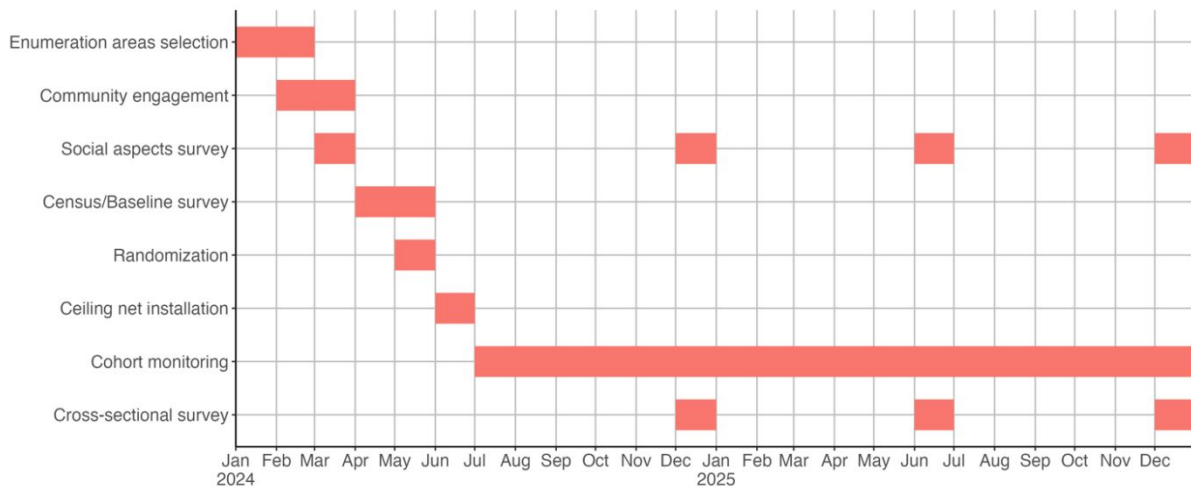


Figure1: Timetable of trial activities

Statistical Principles

Confidence intervals and P values

We will use a two-sided significance level of $\alpha = 0.05$ for hypothesis testing. All statistical tests will be conducted at this predetermined level of significance unless otherwise specified. For each estimated parameter, 95% confidence intervals will be calculated and reported.

Adherence and protocol deviations

Since the intervention (ceiling net) will be installed in trial participants' houses, participants not sleeping in their own houses will not benefit from the intervention. In the cohort, non-adherence to the intervention can be inferred from travel history during monthly interviews. Therefore, participants who regularly sleep outside their homes will be removed from the analyses. In addition, if a cohort participant is absent for three consecutive visits or for more than half of all visits, the child will be excluded from the analysis. Other protocol deviations will be carefully documented and categorized during the study.

Analysis populations

The intention to treat (ITT) analysis is the primary analysis approach for both the primary and secondary objectives. The per-protocol (PP) analysis is included as a supplementary analysis for the primary and secondary objectives.

Trial population

Screening data

Screening data will be collected during the cohort enrollment and each cross-sectional survey to assess the eligibility of potential participants. This information will include demographic characteristics such as age, sex, SES, and other relevant parameters outlined in the study protocol.

Eligibility

The inclusion criteria for the installation of the **pyrethroid-PBO** ceiling net are (1) residential structures housing at least one permanent resident aged 18 years or older in the household, (2) informed consent provided by at least one adult in the household and (3) applicable house structure for the ceiling net in terms of size of the structure, presence of eave, ceiling board, and vertical beams, and material of the top part of the wall. The applicability of the ceiling net installation will be assessed by experienced field staff. The exclusion criteria are (1) vacant dwelling structure (confirmed by at least two visits by CHPs), (2) dwelling structure to be vacated or destroyed within the study period and (3) **non-eligible** house structure for the ceiling net installation.

The inclusion criteria for prospective cohorts of children aged 6 months to 14 years old are (1) living in the study area at the time of **pyrethroid-PBO** ceiling net installation, (2) having no plan to leave or stay outside the study area for an extended period (longer than 1 month) over the 18-month follow-up period, and (3) informed consent provided by the participant's parent or guardian. The exclusion criterion is having severe chronic illnesses.

The inclusion criteria for cross-sectional malaria surveys for all age groups are (1) living in the study area during the study period, and (2) informed consent being provided by the parent or legal guardian before each survey. The exclusion criterion is having severe chronic illnesses.

Recruitment

For the baseline survey, we will randomly choose 50 enumeration areas (comprising one or two villages) in Kanyamwa Kologi Ward, Ndhiwa Sub-County. The survey includes a questionnaire for all households, mRDT testing of all children aged 6 months to 14 years. We will not create buffer zones to minimize contamination since a buffer zone of 400–600 m from the boundary will greatly reduce the number of houses in the core area available for analysis in many clusters. Thirty-eight eligible children will be randomly recruited into our cohort in each cluster. Recruitment will be limited to children aged 12 or younger, to prevent children from aging out during the 18 months monitoring period. For the cross-sectional survey at each time point, we will randomly select 50 individuals of all age groups from each

cluster. To reflect the age structure of the populations, the selection will be done with age category stratifications.

Withdrawal/follow-up

Those who migrate between the arms or emigrate from the study areas, or those who dismount the ceiling net from their house structure will be dropped from the intervention. For the cohort, those who are absent for three consecutive visits or for more than half of all visits will be excluded from the analysis as lost to follow-up. A summary of study participant selection is shown in Figure 2.

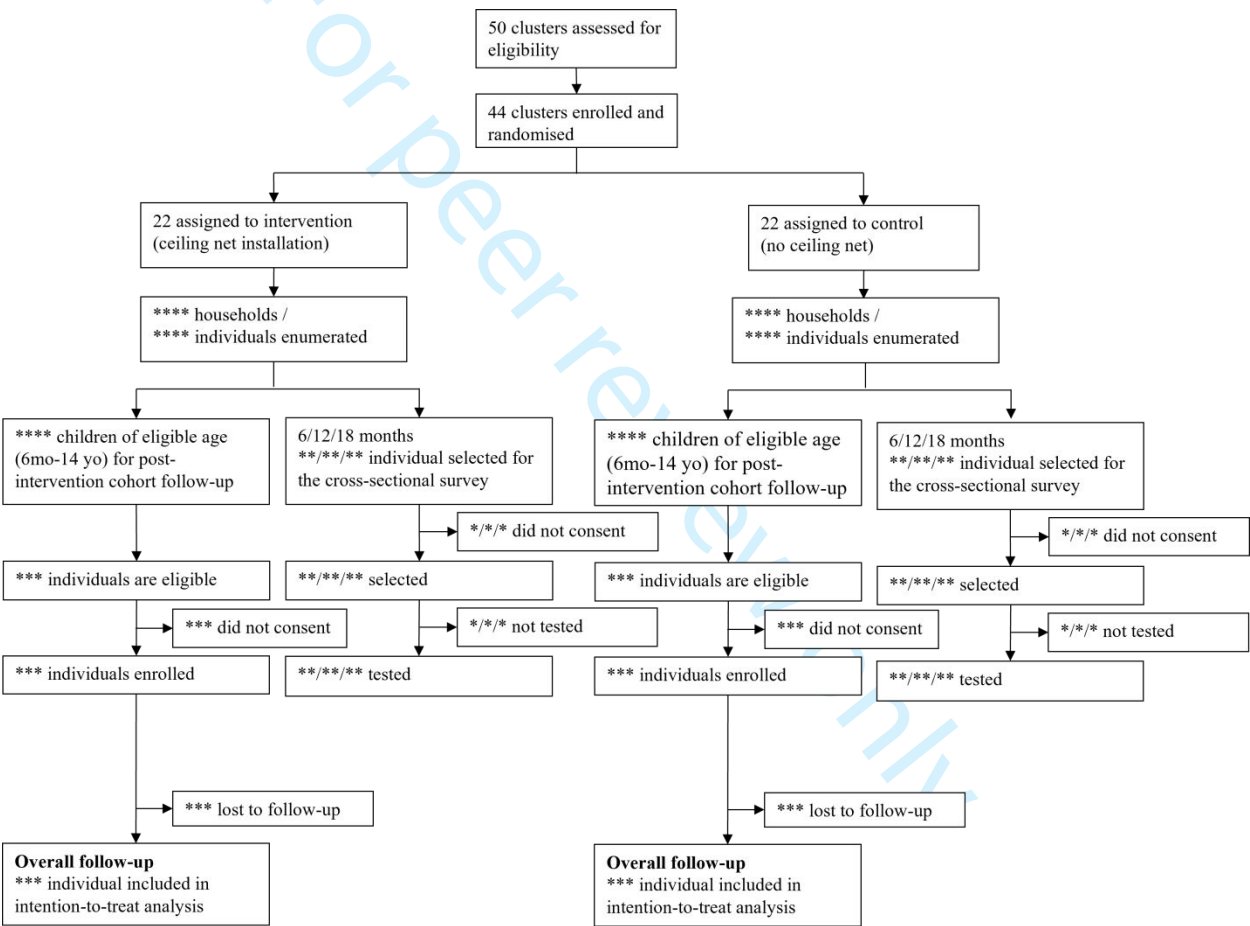


Figure 2: A schematic flow diagram of cluster allocation and study participant selection.

Baseline characteristics

We will report a list of baseline characteristics of the intervention and control arms. The list will include population, mean number of people per household, median age of population, number of selected children

for the cohort monitoring, number of selected individuals for each cross-sectional survey, malaria infection prevalence by RDT in children aged 0.5–14 years, LLIN usage, malaria vaccine coverage among children, SES, the proportion of suitable houses for the ceiling net installation, the mean indoor vectors per household per night.

Analysis

Endpoints

Primary endpoint:

- Overall malaria case incidence in children 6 months-14 years among intervention and control clusters during the 18-month follow-up period.

Secondary endpoints:

1. Malaria infection prevalence by PCR at 6, 12, and 18 months post-intervention in all age groups among intervention and control clusters.
2. Malaria infection incidence by PCR in children 6 months-14 years among intervention and control clusters during the 18-month follow-up period.

Definition of malaria case incidence

Incidence of clinical malaria in the prospective cohort will be estimated by both active and passive case detections. For active case detection, we will visit the home of cohort participants every month. At each monthly visit, axillary temperature will be taken from each cohort participant. A clinical case is defined as positive mRDT accompanied by fever ($>37.5^{\circ}\text{C}$) or any malaria-related symptoms during or within 48 hours of the home visit. All participants with positive mRDT will be treated with artemether-lumefantrine (artemisinin-based combination therapy [ACT]). For passive case detection, we ask all cohort participants to visit designated health facilities in case they suspect malaria between home visits.

If two consecutive RDTs are positive, there are two patterns: active case detection or passive case detection for the detection of the second positive. If the second positive RDT is detected by active case detection, we will refer the child to a health facility and regard it as a new malaria infection if subsequent microscopy or PCR confirms parasites after 15 days or more passed from the first RDT test. If not, it is considered a carryover from the previous infection. For the passive case detection of a second RDT positive, we will regard it as a new malaria infection if more than 14 days have passed since the first RDT test.

For the overall incidence rate calculation, the time at the risk will be adjusted by subtracting the 14 days

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of “protection period” of ACT. If a participant misses a particular visit or a second positive is considered a carryover from the previous infection, the period is not included in the at-risk period.

If the cohort children visit health care facility and get tested for malaria between each visit, both positive and negative results will be utilized for our analysis. Specifically, the 14 days prior to the test result will be incorporated into the denominator of the incidence calculation as the at-risk period. Specific patterns for incidence rate calculation are shown in Figure 3.

If a participant is absent for three consecutive visits or for more than half of all visits, the child will be excluded from the analysis.

Definition of malaria infection incidence

In addition, we will test all cohort children by PCR every month. For the secondary outcome, the infection incidence is defined as the total number of monthly PCR-positive tests per individual divided by the total number of tests conducted per individual per time period, as described in Bennett et al³. If two consecutive PCR results are positive, the second positive result will be removed only if no treatment was provided in the previous month. Furthermore, as a supplementary analysis, we will include passively detected cases in the infection incidence counts to capture any new infections after the passive case treatment by each health center. Passively detected positives will be assigned to the closest active visit—either the one immediately before or after the passive case detection—depending on which is closer in time.

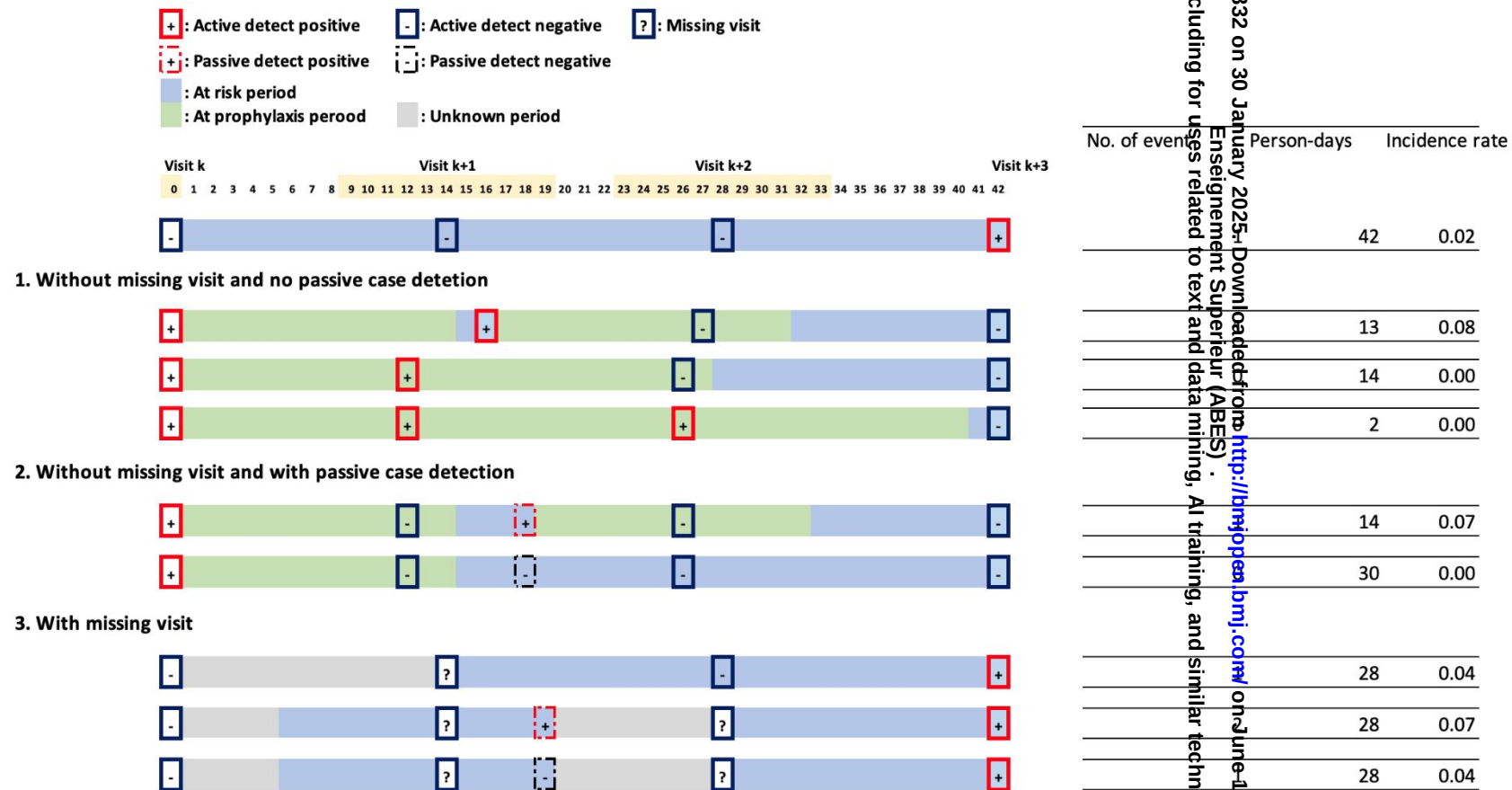


Figure 3: Specific patterns for case incidence rate calculation.

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Analysis methods

We will follow the CONSORT guidelines extended for CRT⁴ for the statistical analysis and results reporting.

Clinical malaria incidence

We will determine the protective efficacy of pyrethroid-PBO ceiling nets against malaria case incidence by comparing clinical malaria incidence rates between arms. We will use mixed effects negative binomial regression accounting for within-cluster correlation of responses by following equations:

$$\mu_{k,i} = \exp(\beta_0 + \mathbf{x}_{k,i}^T \boldsymbol{\beta} + z_k),$$
$$z_k \sim N(0, \sigma^2),$$

where $\mu_{k,i}$ is the mean incidence rate of individual i in cluster k , $\mathbf{x}_{k,i}$ is the covariate vector including individual and cluster level data, z_k is the Gaussian-type random effect at the cluster level. The protective efficacy will be estimated by $(1 - \exp(\hat{\beta})) \times 100\%$, where $\hat{\beta}$ is the estimated regression coefficient of the treatment. Possible confounding factors such as age, sex, bed net usage, house structure, and SES will be adjusted as well as the covariates used in the covariate-constrained randomization. In addition, because we will not set a buffer zone, the distance to the nearest household in the other arm will be adjusted as a covariate to reduce the contamination between two arms. The variable was selected from the previous study⁵.

Prevalence of malaria infection

The secondary outcome, prevalence of malaria infection by PCR and microscopy measured at 6-, 12-, and 18-months after the ceiling net installation will be analyzed using mixed effects logistic regression adjusting for the above-mentioned confounding factors.

Exploratory analysis for spillover effects

Evidence for positive spillover effects of the ceiling net on malaria infection prevalence of all age group will be assessed by comparing individuals with no intervention conditioning 1) the distance to ceiling net installed household, and 2) the coverage of surrounding households with ceiling net within 400 m (Figure 4). The distance of 400 m was chosen as the spillover effect appears to attenuate at this distance based on previous reports⁶. As there may be a bias that households without a ceiling net in the intervention cluster have different characteristics (e.g. preventive behaviour against malaria), we will include only control clusters for the spillover analysis to ensure comparability.

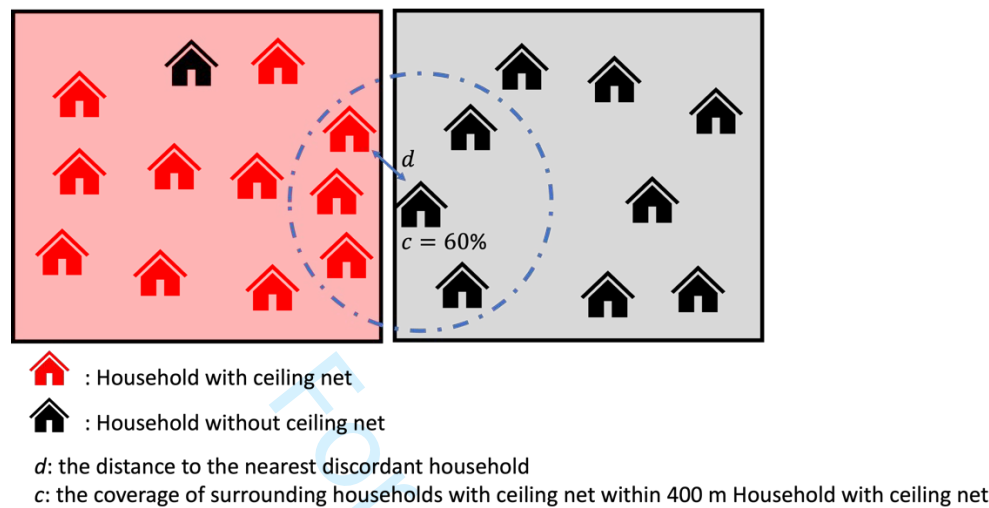


Figure 4: The distance to the nearest discordant household and the coverage of treatment.

Missing data

We will make substantial effort to avoid having missing values on outcome (malaria infection status and visit dates) by encouraging individual participants and CHPs repeatedly. When missing values occur for an outcome for reasons not related to the outcome, reasons for missingness and the missing fraction by treatment arm and cluster will be reported. Per protocol, the subjects are screened actively on their malaria status (the outcome) every four weeks.

In both cases, all the available data from the subject will be included in the primary and secondary analysis, without employing any specific missing data analysis techniques, due to the ignorability of the missing mechanisms. Missing baseline covariates (individual-level, household-level, and cluster-level) that are a part of the regression models for the outcome of interest will be imputed using simple hot-deck imputation methods if the missing fraction for the covariate is $<5\%$. If the missing fraction for a covariable is $\geq 5\%$, appropriate multiple imputation approaches will be applied. If a non-ignorable portion of the subjects have missing values on a covariate (due to missing at random or missing completely at random), that covariate may be excluded in the model.

Additional analysis

We will perform the same analysis for three age subgroups (≤ 59 months old; 5 years old to 14 years old; 15 years old or older) to examine if the effects of **pyrethroid-PBO** ceiling net differ by age groups. In addition, we will perform other machine learning based approach such as causal forest and super learner to estimate the conditional average treatment effect.

Harms

All unanticipated problems will be reported to the research team and Homa Bay County Ministry of Health (MOH) through CHPs. Medical officers from Homa Bay County will assess the relatedness of the reported events to the study and report to the research team, including the PI. In the event of a study-related serious adverse event, the study team will convene a meeting immediately with the MOH and Homa Bay County Teaching and Referral Hospital representatives to review the case and take necessary action. Also, the ceiling net is made of the same materials and chemicals as LLIN already on the market, and is therefore not expected to have significant environmental impact.

Statistical software

For all data handling and analysis, we will use R software version 4.3.2 (R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.)

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0. Consent form

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2Please complete the survey below.

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4Thank you!

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8Please make sure to show the consent form on the tablet.

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10I have read the information about the study and have

11received answers to any questions I asked.

12I consent to take part in all the activities mentioned

13above.

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16Name of participant

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19Signature of participant

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24Name of witness

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27Signature of witness

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32Do you have a child to participate in the study?

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36Check the following box.

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41Parent/Guardian's name

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44Parent/Guardian's signature

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49Witness: I hereby confirm that the study has been

50explained to the parent/ guardian. All questions (if

51any) have also been answered to his/ her satisfaction,

52and he/ she, of his/ her own free will, has consented

53for his/ her child to take part in the study.

54

55Name of witness

56

57Signature of witness

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16 Date _____

Enseignement Supérieur (ABES).

1. Structure

Please complete the survey below.

Thank you!

Longitude

Latitude

Is this structure the first registration in the household?

☐ Yes

☐ No

Record the structure ID of the first structure in this household

(i.g. 12-1-7)

Name of the village

What is the main source of drinking water for members of your household?

☐ PIPED INTO DWELLING

☐ PIPED TO YARD/PLOT

☐ PIPED TO NEIGHBOR

☐ PUBLIC TAP/STANDPIPE

☐ DUG PROTECTED WELL

☐ DUG UNPROTECTED WELL

☐ WATER FROM PROTECTED SPRING

☐ WATER FROM UNPROTECTED SPRING

☐ RAINWATER

☐ TANKER TRUCK

☐ CART WITH SMALL TANK

☐ SURFACE WATER (RIVER/DAM/LAKE/POND/STREAM/CANAL/IRRIGATION CHANNEL)

☐ BOTTLED WATER

☐ OTHER

Specify it.

What is the main source of water used by your household for other purposes such as cooking and handwashing?

☐ PIPED INTO DWELLING

☐ PIPED TO YARD/PLOT

☐ PIPED TO NEIGHBOR

☐ PUBLIC TAP/STANDPIPE

☐ DUG PROTECTED WELL

☐ DUG UNPROTECTED WELL

☐ WATER FROM PROTECTED SPRING

☐ WATER FROM UNPROTECTED SPRING

☐ RAINWATER

☐ TANKER TRUCK

☐ CART WITH SMALL TANK

☐ SURFACE WATER (RIVER/DAM/LAKE/POND/STREAM/CANAL/IRRIGATION CHANNEL)

☐ OTHER

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Specify it.

Where is that water source located?

- ☐ IN OWN DWELLING
☐ IN OWN YARD/PLOT
☐ ELSEWHERE

How long does it take to go there, get water, and come back? (MINUTES)

What kind of toilet facility do members of your household usually use?

IF NOT POSSIBLE TO DETERMINE, ASK PERMISSION TO OBSERVE THE FACILITY.

- ☐ FLUSH TO PIPED SEWER SYSTEM
☐ FLUSH TO SEPTIC TANK
☐ FLUSH TO PIT LATRINE
☐ FLUSH TO SOMEWHERE ELSE
☐ FLUSH, DON'T KNOW WHERE
☐ VENTILATED IMPROVED PIT LATRINE
☐ PIT LATRINE WITH SLAB
☐ PIT LATRINE WITHOUT SLAB/OPEN PIT
☐ COMPOSTING TOILET
☐ BUCKET TOILET
☐ HANGING TOILET/HANGING LATRINE
☐ NO FACILITY/BUSH/FIELD
☐ OTHER

Specify it.

Do you share this toilet facility with other households?

- ☐ Yes
☐ No

Including your own compound, how many households use this toilet facility?

- ☐ LESS THAN 10 HOUSEHOLDS
☐ 10 OR MORE HOUSEHOLDS
☐ DON'T KNOW

Including your own household, how many households use this toilet facility (if less than 10)?

Where is this toilet facility located?

- ☐ IN OWN DWELLING
☐ IN OWN YARD/PLOT
☐ ELSEWHERE

In your household, what type of cooking device (cookstove) is mainly used for cooking?

- ☐ ELECTRIC STOVE
☐ SOLAR COOKER
☐ LIQUEFIED PETROLEUM GAS (LPG)/COOKING GAS STOVE
☐ PIPED NATURAL GAS STOVE
☐ BIOGAS STOVE
☐ LIQUID FUEL STOVE
☐ MANUFACTURED SOLID FUEL STOVE (i.g. Jiko)
☐ THREE STONE STOVE/OPENFIRE
☐ NO FOOD COOKED IN THE HOUSEHOLD
☐ OTHER

Specify it.

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What type of fuel or energy source is mainly used in this cookstove?

☐ ALCOHOL/ETHANOL

☐ GASOLINE/DIESEL

☐ KEROSENE/PARAFFIN

☐ COAL/LIGNITE

☐ CHARCOAL

☐ WOOD

☐ STRAW/SHRUBS/GRASS

☐ AGRICULTURAL CROP

☐ ANIMAL DUNG/WASTE

☐ PROCESSED BIOMASS (PELLETS) OR WOODCHIPS

☐ GARBAGE/PLASTIC

☐ SAWDUST

☐ OTHER

Specify it.

How many rooms in this household are used for sleeping?

Does this household own any livestock, herds, other farm animals, or poultry?

☐ Yes

☐ No

How many of the following (animals) livestock does this household own?

- Local cattle (indigenous)

How many of the following (animals) livestock does this household own?

- Exotic/grade cattle

How many of the following (animals) livestock does this household own?

- Horses

How many of the following (animals) livestock does this household own?

- Donkeys

How many of the following (animals) livestock does this household own?

- Mules

How many of the following (animals) livestock does this household own?

- Goats

How many of the following (animals) livestock does this household own?

- Sheep

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How many of the following (animals) livestock does this household own? _____

- Chickens or other poultry

How many of the following (animals) livestock does this household own? _____

- Pigs

Does any member of this household own any agricultural land?

☐ Yes
☐ No

Do you know how many acres of agricultural land do members of this household own?

☐ Yes
☐ No

How many acres of agricultural land do members of this household own? _____

ACRES

Does your household have:

- ☐ Electricity?
- ☐ A radio?
- ☐ A television?
- ☐ A fixedline telephone?
- ☐ A computer?
- ☐ A refrigerator?
- ☐ A solar panel?
- ☐ A table?
- ☐ A chair?
- ☐ A sofa?
- ☐ A bed?
- ☐ A cupboard?
- ☐ A clock?
- ☐ A microwave oven?
- ☐ A DVD player?
- ☐ A CD player?

Does any member of this compound own:

- ☐ A wrist watch?
- ☐ A mobile phone?
- ☐ A bicycle?
- ☐ A motorcycle or motor scooter?
- ☐ An animal-drawn cart?
- ☐ A car or truck?
- ☐ A boat with a motor?

Does any member of this household have an account in a bank or other financial institution?

☐ Yes
☐ No

Does any member of this household use a mobile phone to make financial transactions such as sending or receiving money, paying bills, purchasing goods or services, or receiving wages?

☐ Yes
☐ No

In the past year, has this household ever used mosquito repellent spray (e.g. Doom), ointments, vaporizers coils, herbs, or plants to protect against mosquitoes/malaria?

☐ Yes
☐ No

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Does your household have any bed nets?

☐ Yes

☐ No

How many mosquito nets does your household have?

Will you accept to install the ceiling net if you are offered?

☐ Yes

☐ No

What is the reason for not installing the ceiling net?
Select all that apply.

☐ Air flow disturbance

☐ Heat

☐ Appearance

☐ Pets

☐ Fire

☐ Social culture and religious factor

☐ Others

Specify it

Do you have any concerns about the ceiling net?
Select all that apply.

☐ Air flow disturbance

☐ Heat

☐ Appearance

☐ Pets

☐ Fire

☐ Social culture and religious factor

☐ No concern

☐ Others

Specify it

OBSERVE MAIN MATERIAL OF THE FLOOR OF THE DWELLING/SLEEPING ROOM.

☐ EARTH/SAND

☐ DUNG

☐ WOOD PLANKS

☐ PALM/BAMBOO

☐ PARQUET OR POLISHED WOOD

☐ VINYL OR ASPHALT STRIPS

☐ CERAMIC TILES

☐ CEMENT

☐ CARPET

☐ OTHER

RECORD OBSERVATION.

Specify it.

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OBSERVE MAIN MATERIAL OF THE ROOF OF THE DWELLING.

RECORD OBSERVATION.

- ☐ NO ROOF
☐ THATCH/PALM LEAF
☐ RUSTIC MAT
☐ PALM/BAMBOO
☐ WOOD PLANKS
☐ CARDBOARD
☐ IRON SHEETS
☐ WOOD
☐ CALAMINE/CEMENT FIBER
☐ BRICK/CLAY TILES
☐ CEMENT
☐ ROOFING SHINGLES
☐ OTHER

Specify it.

OBSERVE MAIN MATERIAL OF THE EXTERIOR WALLS OF THE DWELLING.

RECORD OBSERVATION.

- ☐ NO WALLS
☐ WOOD WITH MUD
☐ IRON SHEET
☐ BRICKS
☐ CANE/PALM/TRUNKS
☐ BAMBOO WITH MUD
☐ STONE WITH MUD
☐ UNCOVERED ADOBE
☐ PLYWOOD
☐ CARDBOARD
☐ REUSED WOOD
☐ CEMENT
☐ STONE WITH LIME/CEMENT
☐ CEMENT BLOCKS
☐ COVERED ADOBE
☐ WOOD PLANKS/SHINGLES
☐ OTHER

Specify it.

OBSERVE EAVES OF THE DWELLING.

RECORD OBSERVATION.

- ☐ Open
☐ Partly open
☐ Close

OBSERVE BEAMS OF THE DWELLING.

RECORD OBSERVATION.

- ☐ No vertical beam
☐ One vertical beam
☐ More than one vertical beams

Tick all that apply

- ☐ 2 or more vertical beams in the same room
☐ Ceiling board/ Flat roof
☐ The roof is very low
☐ The room is used for kitchen
☐ None

Has this structure been done with IRS (Indoor Residual Spraying) within three years?

- ☐ Yes
☐ No

When did you have IRS?

- ☐ 2021
☐ 2022
☐ 2023
☐ Don't know

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Is there a child living in this structure?

☐ Yes

☐ No

"Living" means that the child usually stay in the household. If the child is usually staying at a boarding school, but now he/she is staying in this house because of a school closure, that is not regarded as "living".

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Once you complete, "Show More Save Options">"Save & Go to Next Form"

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2. Children

Please complete the survey below.

Thank you!

Skip this page because there is no children and "Show More Save Options">"Save & Go to Next Form".

Now we would like to record the names of all children aged under 18.

But RDT tests are for children from 6 month to 14 years old.

RECORD TWINS AND TRIPLETS SEPARATELY.

What name was given to the child?

First name

What name was given to the child?

Middle name

What name was given to the child?

Last name

Is the child a boy or a girl?

- ☐ BOY
☐ GIRL

Was that a single or multiple pregnancy?

- ☐ SING
☐ MULT

Do you know the birthday of the child?

- ☐ Yes
☐ No

On what day, month, and year was the child born?

How old was the child at the last birthday?

The birthday and your age are contradicting. Please check the true age again.

Is the child living with you?

- ☐ Yes
☐ No

"Living with" means that you and the child usually stay in the same household. If the child is usually staying at a boarding school, but now he/she is being with you because of a school closure, that is not regarded as "living with you".

Has the child been ill with a fever at any time in the last 2 weeks?

- ☐ YES
☐ NO
☐ DON'T KNOW

1

At any time during the illness, did the child have

2

blood taken from a finger or heel for testing?

3

☐ YES

☐ NO

☐ DON'T KNOW

4

5

Were you told by a healthcare provider that the child

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had malaria?

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☐ YES

☐ NO

☐ DON'T KNOW

8

9

Did you seek advice or treatment for the illness from

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any source?

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☐ Yes

☐ No

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How many times did you seek advice or treatment for

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the illness from any source?

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Where did you first seek advice or treatment? Anywhere

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else?

18

☐ GOVERNMENT HOSPITAL

☐ GOVERNMENT HEALTH CENTER

☐ GOVERNMENT DISPENSARY

☐ GOVERNMENT MOBILE CLINIC

☐ COMMUNITY HEALTH WORKER/FIELD WORKER

☐ PRIVATE HOSPITAL

☐ PRIVATE CLINIC

☐ PHARMACY

☐ PRIVATE DOCTOR

☐ PRIVATE MOBILE CLINIC

☐ COMMUNITY HEALTH WORKER

☐ SHOP

☐ TRADITIONAL PRACTITIONER

☐ MARKET

☐ ITINERANT DRUG SELLER

☐ OTHER

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PROBE TO IDENTIFY THE TYPE OF SOURCE.

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IF UNABLE TO DETERMINE IF PUBLIC, PRIVATE, OR NGO

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SECTOR, RECORD 'OTHER'

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Specify it.

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Where did you second seek advice or treatment?

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Anywhere else?

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☐ GOVERNMENT HOSPITAL

☐ GOVERNMENT HEALTH CENTER

☐ GOVERNMENT DISPENSARY

☐ GOVERNMENT MOBILE CLINIC

☐ COMMUNITY HEALTH WORKER/FIELD WORKER

☐ PRIVATE HOSPITAL

☐ PRIVATE CLINIC

☐ PHARMACY

☐ PRIVATE DOCTOR

☐ PRIVATE MOBILE CLINIC

☐ COMMUNITY HEALTH WORKER

☐ SHOP

☐ TRADITIONAL PRACTITIONER

☐ MARKET

☐ ITINERANT DRUG SELLER

☐ OTHER

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PROBE TO IDENTIFY THE TYPE OF SOURCE.

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IF UNABLE TO DETERMINE IF PUBLIC, PRIVATE, OR NGO

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SECTOR, RECORD 'OTHER'

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Specify it.

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Where did you third seek advice or treatment? Anywhere else?

PROBE TO IDENTIFY THE TYPE OF SOURCE.

IF UNABLE TO DETERMINE IF PUBLIC, PRIVATE, OR NGO SECTOR, RECORD 'OTHER'

- ☐ GOVERNMENT HOSPITAL
- ☐ GOVERNMENT HEALTH CENTER
- ☐ GOVERNMENT DISPENSARY
- ☐ GOVERNMENT MOBILE CLINIC
- ☐ COMMUNITY HEALTH WORKER/FIELD WORKER
- ☐ PRIVATE HOSPITAL
- ☐ PRIVATE CLINIC
- ☐ PHARMACY
- ☐ PRIVATE DOCTOR
- ☐ PRIVATE MOBILE CLINIC
- ☐ COMMUNITY HEALTH WORKER
- ☐ SHOP
- ☐ TRADITIONAL PRACTITIONER
- ☐ MARKET
- ☐ ITINERANT DRUG SELLER
- ☐ OTHER

Specify it.

How many days after the illness began did you first seek advice or treatment for the child?

IF THE SAME DAY RECORD '0'.

At any time during the illness, did the child take any medicine for the illness?

- ☐ Yes
- ☐ No

What medicine did the child take? Any other medicine?

RECORD ALL MENTIONED.
IF MEDICINE NOT KNOWN, ASK TO SEE THE PACKAGE OR PRESCRIPTION.

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOTALORDHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER
- ☐ DON'TKNOW

Specify it.

How long after the fever started did the child first take an artemisinin-based combination therapy?

- ☐ SAME DAY
- ☐ NEXT DAY
- ☐ TWO DAYS AFTER FEVER
- ☐ THREE OR MORE DAYS AFTER FEVER
- ☐ DON'TKNOW

Has [mis_wo213_1] received a malaria vaccine?

- ☐ Yes
- ☐ No

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How many times has [mis_wo213_1] received malaria vaccine?

☐ 1 dose

☐ 2 doses

☐ 3 doses

☐ 4 doses

☐ Don't know

Where does [mis_wo213_1] usually sleep?

☐ Bed room

☐ Kitchen room

☐ Others

Specify it.

Where Is [mis_wo213_1] usually living?

☐ This household

☐ Boarding school

☐ Relative's house outside the village

☐ Others

Specify it.

Did [mis_wo213_1] spend any nights outside your house in the last 30 days?

☐ Yes

☐ No

Where did [mis_wo213_1] spend those nights?

☐ Another house in Ndhiwa Sub-county

☐ Homa Bay county other than Ndhiwa

☐ Another county in Kenya

☐ Another country

How many nights did [mis_wo213_1] spend in another house in Ndhiwa?

How many nights did [mis_wo213_1] spend in another house in Homa Bay County other than Ndhiwa?

Specify the Sub-county name.

How many nights did [mis_wo213_1] spend in another house in another county in Kenya?

Specify the county name.

How many nights did [mis_wo213_1] spend in another house in another country?

Specify the country name.

Did the child sleep under a bed net last night?

☐ Yes

☐ No

RDT result for P.f

☐ Negative

☐ Positive

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RDT result for Pan

☐ Negative

☐ Positive

If there is another child, press "Show More Save Options">"Save & Add New Instance

otherwise, press "Show More Save Options">"Go to Next Form".

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3. Adults

Please complete the survey below.

Thank you!

Now, we would like to record the names of all adults who live in this household on a permanent or weekly basis. Do not include a person who stays only a few days in a month.

First name

Middle name

Last name

Choose from the below.

Sleep in this structure...

More than half of the week = Permanent

Few days in a week regularly = Weekly

Few days in a month regularly = Monthly

Other type of resident

- ☐ Permanent Resident
- ☐ Weekly Resident
- ☐ Monthly Resident
- ☐ Others

Answer his/her age with...

- ☐ birthday
- ☐ age
- ☐ age group

Birthday

Age

(years old)

Age group

- ☐ High school
- ☐ After high school
- ☐ Was born before the independence of Kenya

Sex

- ☐ Male
- ☐ Female
- ☐ Other
- ☐ Prefer not to say

1 Relation to the structure head

- ☐ Head
- ☐ Spouse (Husband or wife 1)
- ☐ Wife 2 or 3
- ☐ Parent
- ☐ Parent in law
- ☐ Child
- ☐ Child in law
- ☐ Brother/Sister
- ☐ Brother/Sister in law
- ☐ Grand Child
- ☐ Nephew/Niece
- ☐ Uncle/Aunt
- ☐ Worker
- ☐ Other relative
- ☐ Other non-relative

17 Relation to the compound head

- ☐ Head
- ☐ Spouse (Husband or wife 1)
- ☐ Wife 2 or 3
- ☐ Parent
- ☐ Parent in law
- ☐ Child
- ☐ Child in law
- ☐ Brother/Sister
- ☐ Brother/Sister in law
- ☐ Grand Child
- ☐ Nephew/Niece
- ☐ Uncle/Aunt
- ☐ Worker
- ☐ Other relative
- ☐ Other non-relative

32 Please repeat until you record all the members.
33 ("Show More Save Options">"Save & Add New Instance").

37 Once you complete all the member,
38 "Show More Save Options">"Save & Go to Next Form".

40 Note

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4. NET

Please complete the survey below.

Thank you!

ASK THE RESPONDENT TO SHOW YOU ALL THE NETS IN THE HOUSEHOLD. OBSERVE AND ANSWER THE QUESTIONS FOR EACH NET, ONE BY ONE.

Please name this net for the sake of identification.
i.e. boy's net, parent's net, net in the living room....

WAS THIS NET OBSERVED?

☐ Yes

☐ No

How many months ago did your household get the mosquito net?
IF LESS THAN ONE MONTH AGO, RECORD '00'.

☐ 0

☐ 1

☐ 2

☐ 3

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☐ 32

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☐ 34

☐ 35

☐ 36

☐ MORE THAN 36 MONTHS AGO

☐ NOT SURE

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OBSERVE OR ASK BRAND/TYPE OF MOSQUITO NET.

- ☐ OLYSET (SUPANET EXTRA)
☐ PERMANET (SUPANET EXTRA)
☐ VEERALIN
☐ NETPROTECT
☐ YORKKOL
☐ DAWAPLUS
☐ OTHER/DON'T KNOW BRAND (LLIN)
☐ OTHER TYPE (NOT LLIN)
☐ DON'T KNOW TYPE

Did you get the net through a distribution campaign, during an antenatal care visit, or during a child welfare visit?

- ☐ YES, MASS DISTRIBUTION CAMPAIGN
☐ YES, ANTENATAL CARE VISIT
☐ YES, CHILD WELFARE VISIT
☐ NO

Where did you get the net?

- ☐ GOVERNMENT HEALTH FACILITY
☐ PRIVATE HEALTH FACILITY
☐ PHARMACY
☐ SHOP/MARKET
☐ CHP
☐ RELIGIOUS INSTITUTION
☐ SCHOOL
☐ OTHER
☐ DON'T KNOW

Did anyone sleep under this mosquito net last night?

- ☐ YES
☐ NO
☐ NOT SURE

Who slept under this mosquito net last night?

RECORD THE PERSON'S NAME. IF THERE ARE MORE THAN ONE, RECORD ALL THE NAME CONNECTING BY ",".

What was the main reason this net was not used last night?

- ☐ TOO HOT
☐ DON'T LIKE NET SHAPE/COLOR/SIZE
☐ DON'T LIKE SMELL
☐ UNABLE TO HANG NET
☐ SLEPT OUTDOORS
☐ USUAL USER DIDN'T SLEEP HERE LAST NIGHT
☐ NO MOSQUITOES/NO MALARIA
☐ EXTRA NET/SAVING FOR LATER
☐ NET TOO SMALL/SHORT
☐ NET BROUGHT BED BUGS
☐ OTHER

Specify it

Note

If there is another net, press "Show More Save Options">"Save & Add New Instance

otherwise, press "Save & Exit Form".

Questionnaire

1

2Please complete the survey below.

3

4Thank you!

5

6

7

8Date and time of visit

9

10

11Cohort ID

12

13(i.e. "2_1")

14

15Cluster ID is incorrect.

16

17

18Structure ID

19

20(Typing the ID shown on the structure. i.e,

21"malela-10-10")

22

23First name

24

25

26Middle name

27

28

29

30Last name

31

32

33This participant is available for the survey.

34

35

36Please select the reason why the participant is not

37available.

38

39

40

41

42

43

44

45Please indicate when he/she will be back.

46(If you do not know, please write 0.)

47

48Specify the reason.

49

50

51

52Did [name_f] spend any nights outside [name_f]'s house

53in the last four weeks?

54

55Where did [name_f] spend those nights?

56

57

58

59

60

☐ Yes

☐ No

☐ Moved out from the area (will never come back)

☐ Travel to another village in Ndhiwa

☐ Travel to Homa Bay County other than Ndhiwa

☐ Travel to Another county in Kenya

☐ Travel to Another country

☐ Refuse

☐ Do not know (Could not find)

☐ Others

☐ Another house in your village

☐ Another village in Ndhiwa

☐ Homa Bay County other than Ndhiwa

☐ Another county in Kenya

☐ Another country

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How many nights did [name_f] spend in another house in [name_f]'s village?

Did you see the ceiling nets in the household you visited in another house in the village?

☐ Yes
☐ No

How many nights did [name_f] spend in another village in Ndhiwa?

Did you see the ceiling nets in the household you visited in another village in Ndhiwa?

☐ Yes
☐ No

How many nights did [name_f] spend in Homa Bay County other than Mfangano and Mbita?

How many nights did [name_f] spend in another county in Kenya?

How many nights did [name_f] spend in another country?

Did [name_f] visit any health facility in the last four weeks?

☐ Yes
☐ No

(Please refer to the booklet)

Did [name_f] have the following symptoms at any point in the past four weeks?

- ☐ Fever
- ☐ Chills
- ☐ Profuse sweating
- ☐ Muscle/joint pain
- ☐ Abdominal pain
- ☐ Diarrhoea
- ☐ Nausea
- ☐ Vomiting
- ☐ Irritability
- ☐ Refusal to feed
- ☐ Prostration (difficulty to sit upright)
- ☐ Alteration in the level of consciousness
- ☐ Convulsions or coma
- ☐ Difficulty in breathing/respiratory distress
- ☐ Jaundice
- ☐ Others
- ☐ None

Please list other symptoms [name_f] experienced in the past four weeks.

How many times did the child visit health facilities?

- ☐ One time
- ☐ Two time
- ☐ Three time
- ☐ More than three

1

When did [name_f]visit the health facility?

2

3

4

5

(Please refer to the booklet)

6

7

Which health facility did [name_f] visit?

8

9

(Please refer to the booklet)

10

11

12

13

14

15

16

☐ Malela level 4 hospital

☐ Kabongo HC

☐ Andiwo HC

☐ Wikomimo HC

☐ Abuoro HC

☐ Langi HC

☐ Kobodo HC

☐ Okok HC

☐ Other

17

Please state the health facility [name_f] visited.

18

19

20

Which symptoms did the child have?

21

22

(Please refer to the booklet)

23

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☐ Fever

☐ Headache

☐ Muscle pain

☐ Abdominal pain

☐ Nausea

☐ Vomiting

☐ Diarrhea

☐ Convulsions or coma

☐ Jaundice

☐ Rapid breathing

☐ Difficulty in breathing/respiratory distress

☐ Pale conjunctivae/palms

☐ Loss of reactivity

☐ Others

35

When did the symptom start?

36

37

38

39

(Please refer to the booklet)

40

41

Was [name_f] diagnosed with malaria?

42

43

(Please refer to the booklet)

44

45

☐ Yes

☐ No

46

What was the diagnosis?

47

48

49

Did [name_f] take any treatment or medication?

50

51

(Please refer to the booklet)

52

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What treatment or medication did [name_f] receive from the health facility?

(Please refer to the booklet)

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOT AL OR DHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER
- ☐ DON'TKNOW

Please list other medications [name_f] received from the health facility.

When did [name_f] FIRST visit the health facility?

(Please refer to the booklet)

Which health facility did [name_f] first visit?

(Please refer to the booklet)

- ☐ Malela level 4 hospital
- ☐ Kabongo HC
- ☐ Andiwo HC
- ☐ Wikomimo HC
- ☐ Abuoro HC
- ☐ Langi HC
- ☐ Kobodo HC
- ☐ Okok HC
- ☐ Other

Please state the health facility [name_f] visited.

Which symptoms did the child have at the first visit?

(Please refer to the booklet)

- ☐ Fever
- ☐ Headache
- ☐ Muscle pain
- ☐ Abdominal pain
- ☐ Nausea
- ☐ Vomiting
- ☐ Diarrhea
- ☐ Convulsions or coma
- ☐ Jaundice
- ☐ Rapid breathing
- ☐ Difficulty in breathing/respiratory distress
- ☐ Pale conjunctivae/palms
- ☐ Loss of reactivity
- ☐ Others

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When did the symptoms for the first visit start?

(Please refer to the booklet)

Was [name_f] diagnosed with malaria for the first visit?

Yes

No

(Please refer to the booklet)

What was the diagnosis?

Did [name_f] take any treatment or medication for the first visit?

Yes

No

(Please refer to the booklet)

What treatment or medication did [name_f] receive from the health facility?

AL

DHAP

OTHER ACT (NOT AL OR DHAP)

SP/FANSIDAR

CHLOROQUINE

AMODIAQUINE

QUININE (PILLS)

QUININE (INJECTION/IV)

ARTESUNATE (RECTAL)

ARTESUNATE (INJECTION/IV)

OTHER ANTIMALARIAL

AMOXICILLIN

COTRIMOXAZOLE

OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

ASPIRIN

PARACETAMOL/PANADOL/ACETAMINOPHEN

IBUPROFEN

OTHER

DON'TKNOW

(Please refer to the booklet)

Please list other medications [name_f] received from the health facility.

When did [name_f] SECOND visit the health facility?

(Please refer to the booklet)

Which health facility did [name_f] second visit?

Malela level 4 hospital

Kabongo HC

Andiwo HC

Wikomimo HC

Abuoro HC

Langi HC

Kobodo HC

Okok HC

Other

(Please refer to the booklet)

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Please state the health facility [name_f] visited.

Which symptoms did the child have at the second visit?

(Please refer to the booklet)

- ☐ Fever
- ☐ Headache
- ☐ Muscle pain
- ☐ Abdominal pain
- ☐ Nausea
- ☐ Vomiting
- ☐ Diarrhea
- ☐ Convulsions or coma
- ☐ Jaundice
- ☐ Rapid breathing
- ☐ Difficulty in breathing/respiratory distress
- ☐ Pale conjunctivae/palms
- ☐ Loss of reactivity
- ☐ Others

When did the symptoms for the second visit start?

(Please refer to the booklet)

Was [name_f] diagnosed with malaria for the second visit?

- ☐ Yes
- ☐ No

(Please refer to the booklet)

What was the diagnosis?

Did [name_f] take any treatment or medication for the second visit?

- ☐ Yes
- ☐ No

(Please refer to the booklet)

What treatment or medication did [name_f] receive from the health facility?

(Please refer to the booklet)

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOT AL OR DHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER
- ☐ DON'TKNOW

Please list other medications [name_f] received from the health facility.

1

When did [name_f] THIRD visit the health facility?

2

3

4

5

(Please refer to the booklet)

6

7

Which health facility did [name_f] third visit?

8

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☐ Malela level 4 hospital

☐ Kabongo HC

☐ Andiwo HC

☐ Wikomimo HC

☐ Abuoro HC

☐ Langi HC

☐ Kobodo HC

☐ Okok HC

☐ Other

17

Please state the health facility [name_f] visited.

18

19

20

Which symptoms did the child have at the third visit?

21

22

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☐ Fever☐ Headache☐ Muscle pain☐ Abdominal pain☐ Nausea☐ Vomiting☐ Diarrhea☐ Convulsions or coma☐ Jaundice☐ Rapid breathing☐ Difficulty in breathing/respiratory distress☐ Pale conjunctivae/palms☐ Loss of reactivity☐ Others

35

When did the symptoms for the third visit start?

36

37

38

39

(Please refer to the booklet)

40

41

Was [name_f] diagnosed with malaria for the third visit?

42

43

44

(Please refer to the booklet)

45

☐ Yes☐ No

46

What was the diagnosis?

47

48

49

50

Did [name_f] take any treatment or medication for the third visit?

51

52

53

(Please refer to the booklet)

54

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☐ Yes☐ No

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1 What treatment or medication did [name_f] receive from
2 the health facility?

3
4 (Please refer to the booklet)

- 5 ☐ AL
6 ☐ DHAP
7 ☐ OTHER ACT (NOT AL OR DHAP)
8 ☐ SP/FANSIDAR
9 ☐ CHLOROQUINE
10 ☐ AMODIAQUINE
11 ☐ QUININE (PILLS)
12 ☐ QUININE (INJECTION/IV)
13 ☐ ARTESUNATE (RECTAL)
14 ☐ ARTESUNATE (INJECTION/IV)
15 ☐ OTHER ANTIMALARIAL
16 ☐ AMOXICILLIN
17 ☐ COTRIMOXAZOLE
18 ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
19 ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
20 ☐ ASPIRIN
21 ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
22 ☐ IBUPROFEN
23 ☐ OTHER
24 ☐ DON'TKNOW

25 Please list other medications [name_f] received from
26 the health facility.

27 Did [name_f] take treatment or medication from the
28 following in the past four weeks?

- 29 ☐ No
30 ☐ Friends
31 ☐ Relatives
32 ☐ Pharmacy/chemist
33 ☐ Traditional healers

34 What medications did [name_f] take from the friends?

- 35 ☐ AL
36 ☐ DHAP
37 ☐ OTHER ACT (NOT AL OR DHAP)
38 ☐ SP/FANSIDAR
39 ☐ CHLOROQUINE
40 ☐ AMODIAQUINE
41 ☐ QUININE (PILLS)
42 ☐ QUININE (INJECTION/IV)
43 ☐ ARTESUNATE (RECTAL)
44 ☐ ARTESUNATE (INJECTION/IV)
45 ☐ OTHER ANTIMALARIAL
46 ☐ AMOXICILLIN
47 ☐ COTRIMOXAZOLE
48 ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
49 ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
50 ☐ ASPIRIN
51 ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
52 ☐ IBUPROFEN
53 ☐ OTHER
54 ☐ DON'TKNOW

55 Please list other medications [name_f] took from the
56 friends.

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What medications did [name_f] take from the relatives?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

☐ DON'TKNOW

Please list other medications [name_f] took from the relatives.

What medications did [name_f] take from the pharmacy/chemist?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

☐ DON'TKNOW

Please list other medications [name_f] took from the pharmacy.

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What medications did [name_f] take from the traditional healer?

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOT AL OR DHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER
- ☐ DON'TKNOW

Please list other medications [name_f] took from the traditional healer.

Does [name_f] have the following symptoms now or in the last 24 hours?

- ☐ Fever
- ☐ Chills
- ☐ Profuse sweating
- ☐ Muscle/joint pain
- ☐ Abdominal pain
- ☐ Diarrhoea
- ☐ Nausea
- ☐ Vomiting
- ☐ Irritability
- ☐ Refusal to feed
- ☐ Prostration (difficulty to sit upright)
- ☐ Alteration in the level of consciousness
- ☐ Convulsions or coma
- ☐ Difficulty in breathing/respiratory distress
- ☐ Jaundice
- ☐ Others
- ☐ None

Please list other symptoms [name_f] experience now or in the last 24 hours.

Did [name_f] receive the malaria vaccine within four weeks?

- ☐ Yes
- ☐ No

How many times has [name_f] received the malaria vaccine, including the latest one?

- ☐ 1 dose
- ☐ 2 doses
- ☐ 3 doses
- ☐ 4 doses
- ☐ Don't know

Does the structure where [name_f] usually sleeps have ceiling nets?

- ☐ Yes
- ☐ No

Sample

1
2 Please complete the survey below.
3
4 Thank you!

5
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11 Cohort ID

12

13

14

15 First name

16

17

18 Middle name

19

20

21 Last name

22

23

24 Did you sleep under a bed net last night?

25 ☐ Yes

26 ☐ No

27

28 Axillary temperature (degrees Celsius)

29

30

31 Perform finger prick

32 ☐ Yes

33 ☐ No

34

35 Blood spots on filter paper?

36 ☐ Yes

37 ☐ No

38

39 Thick and thin blood films?

40 ☐ Yes

41 ☐ No

42

43 RDT results for P.f

44 ☐ Negative

45 ☐ Positive

46

47 RDT results for Pan

48 ☐ Negative

49 ☐ Positive

50

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Participant questionnaire

Please complete the survey below.

Thank you!

Date and time of visit

Date and time of visit

Survey ID

(i.e. "s2_1")

Structure ID

(Typing the ID shown on the structure. i.e. "malela-10-10")

First name

Middle name

Last name

Age

(years old)

Does [name_f] know the birthday?

- ☐ Yes
☐ No

Birthday

The birthday and your age are contradicting. Please check the true age again.

Sex

- ☐ Male
☐ Female
☐ Other
☐ Prefer not to say

Longitude

Latitude

This participant is available for the survey.

- ☐ Yes
☐ No

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Please select the reason why the participant is not available.

Specify the reason.

Did [name_f] spend any nights outside [name_f]'s house in the last four weeks?

Where did [name_f] spend those nights?

How many nights did [name_f] spend in another house in [name_f]'s village?

Did you see the ceiling nets in the household you visited in another house in the village?

How many nights did [name_f] spend in another village in Ndhiwa?

Did you see the ceiling nets in the household you visited in another village in Ndhiwa?

How many nights did [name_f] spend in Homa Bay County other than Ndhiwa?

How many nights did [name_f] spend in another county in Kenya?

How many nights did [name_f] spend in another country?

Did [name_f] have any symptoms at any point in the past four weeks?

☐ Moved out from the area (will never come back)

☐ Travel to another village in Ndhiwa

☐ Travel to Homa Bay County other than Ndhiwa

☐ Travel to Another county in Kenya

☐ Travel to Another country

☐ Refuse

☐ Do not know (Could not find)

☐ Others

☐ Yes

☐ No

☐ Another house in your village

☐ Another village in Ndhiwa

☐ Homa Bay County other than Ndhiwa

☐ Another county in Kenya

☐ Another country

☐ Yes

☐ No

☐ Yes

☐ No

☐ Yes

☐ No

☐ Don't know

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What was the symptom? Tick all that apply.

- ☐ Fever
- ☐ Chills
- ☐ Profuse sweating
- ☐ Muscle/joint pain
- ☐ Abdominal pain
- ☐ Diarrhoea
- ☐ Nausea
- ☐ Vomiting
- ☐ Irritability
- ☐ Refusal to feed
- ☐ Prostration (difficulty to sit upright)
- ☐ Alteration in the level of consciousness
- ☐ Convulsions or coma
- ☐ Difficulty in breathing/respiratory distress
- ☐ Jaundice
- ☐ Cough
- ☐ Rash
- ☐ Itches
- ☐ Others

Please list other symptoms [name_f] experienced in the past four weeks.

Did [name_f] visit any health facility in the last four weeks?

- ☐ Yes
- ☐ No

Which health facility did [name_f] visit?

- ☐ Malela level 4 hospital
- ☐ Kabongo HC
- ☐ Andiwo HC
- ☐ Wikomimo HC
- ☐ Abuoro HC
- ☐ Langi HC
- ☐ Kobodo HC
- ☐ Okok HC
- ☐ Other

Please state the health facility [name_f] visited.

Was [name_f] diagnosed with malaria?

- ☐ Yes
- ☐ No

What was the diagnosis?

Did [name_f] take any treatment or medication?

- ☐ Yes
- ☐ No

Do you know the name of the medication?

- ☐ Yes
- ☐ No

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What treatment or medication did [name_f] receive from the health facility?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

Please list other medications [name_f] received from the health facility.

Did [name_f] take treatment or medication from friends, relatives, pharmacy/chemist, or traditional healers in the past four weeks?

☐ Yes

☐ No

Did [name_f] take treatment or medication from the following in the past four weeks?

☐ Friends

☐ Relatives

☐ Pharmacy/chemist

☐ Traditional healers

Do you know the names of medications from your friends?

☐ Yes

☐ No

What medications did [name_f] take from the friends?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

Please list other medications [name_f] took from the friends.

Do you know the names of medications from your relatives?

☐ Yes

☐ No

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What medications did [name_f] take from the relatives?

- ☐ AL
☐ DHAP
☐ OTHER ACT (NOT AL OR DHAP)
☐ SP/FANSIDAR
☐ CHLOROQUINE
☐ AMODIAQUINE
☐ QUININE (PILLS)
☐ QUININE (INJECTION/IV)
☐ ARTESUNATE (RECTAL)
☐ ARTESUNATE (INJECTION/IV)
☐ OTHER ANTIMALARIAL
☐ AMOXICILLIN
☐ COTRIMOXAZOLE
☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
☐ ASPIRIN
☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
☐ IBUPROFEN
☐ OTHER

Please list other medications [name_f] took from the relatives.

Do you know the names of medications from the pharmacy/chemist?

- ☐ Yes
☐ No

What medications did [name_f] take from the pharmacy/chemist?

- ☐ AL
☐ DHAP
☐ OTHER ACT (NOT AL OR DHAP)
☐ SP/FANSIDAR
☐ CHLOROQUINE
☐ AMODIAQUINE
☒ QUININE (PILLS)
☐ QUININE (INJECTION/IV)
☒ ARTESUNATE (RECTAL)
☐ ARTESUNATE (INJECTION/IV)
☒ OTHER ANTIMALARIAL
☐ AMOXICILLIN
☐ COTRIMOXAZOLE
☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
☐ ASPIRIN
☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
☐ IBUPROFEN
☐ OTHER

Please list other medications [name_f] took from the pharmacy.

Do you know the names of medications from the traditional healer?

- ☐ Yes
☐ No

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What medications did [name_f] take from the traditional healer?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

Please list other medications [name_f] took from the traditional healer.

Does [name_f] have any symptoms now or in the last 24 hours?

☐ Yes

☐ No

Does [name_f] have the following symptoms now or in the last 24 hours?

☐ Fever

☐ Chills

☐ Profuse sweating

☐ Muscle/joint pain

☐ Abdominal pain

☐ Diarrhoea

☐ Nausea

☐ Vomiting

☐ Irritability

☐ Refusal to feed

☐ Prostration (difficulty to sit upright)

☐ Alteration in the level of consciousness

☐ Convulsions or coma

☐ Difficulty in breathing/respiratory distress

☐ Jaundice

☐ Cough

☐ Rash

☐ Itches

☐ Others

Please list other symptoms [name_f] experience now or in the last 24 hours.

Has [name_f] received a malaria vaccine?

☐ Yes

☐ No

Please refer to the mother-child book.

How many times has [name_f] received the malaria vaccine?

☐ 1 dose

☐ 2 doses

☐ 3 doses

☐ 4 doses

☐ Don't know

Please refer to the mother-child book.

Does the structure where [name_f] usually sleeps have ceiling nets?

☐ Yes

☐ No

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Sample

Please complete the survey below.

Thank you!

Survey ID

First name

Middle name

Last name

Did you sleep under a bed net last night?

- ☐ Yes
- ☐ No

Axillary temperature (degrees Celsius)

Perform finger prick

- ☐ Yes
- ☐ No

Blood spots on filter paper?

- ☐ Yes
- ☐ No

Thick and thin blood films?

- ☐ Yes
- ☐ No

RDT results for P.f

- ☐ Negative
- ☐ Positive

RDT results for Pan

- ☐ Negative
- ☐ Positive

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Head questionnaire

Please complete the survey below.

Thank you!

Who is the respondent?

☐ Head

☐ Primary care taker

☐ Participant

☐ Others

*If the respondent are not sure about the answer(s), he/she can be helped by the other members.

What is the respondent's relation to the participant?

☐ Head

☐ Spouse (Husband or wife 1)

☐ Wife 2 or 3

☐ Parent

☐ Parent in law

☐ Child

☐ Child in law

☐ Brother/Sister

☐ Brother/Sister in law

☐ Grand Child

☐ Nephew/Niece

☐ Uncle/Aunt

☐ Worker

☐ Other relative

☐ Other non-relative

What is the condition of the ceiling net?

☐ No damage

☐ Damaged and not repaired

☐ Damaged but repaired

☐ Removed

☐ Not installed

How many hole(s) does/did it have?
(regardless of the size)
(mark 0 if no hole)

Where are the hole(s) located?

☐ Around the edge (lower part, near the wall)

☐ Around the top

☐ In the middle

What is/was the size of largest hole?

☐ smaller than the tip of index finger

☐ smaller than the fist

☐ larger than the fist

What is/was the reason of the damage?

☐ Accident during the cleaning

☐ Animal

☐ Caught a fire

☐ Unknown

☐ Others

Please specify the reason of the damage

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Why did they remove?

What is the condition of the wooden battens securing the ceiling net to the wall?

- ☐ Good
☐ Damaged

Presence of gaps between battens and the wall

- ☐ Yes
☐ No

Do you agree with the following potential positive sides of the ceiling net?

- ☐ Stop mosquito entering the house
☐ Stop other insects/animals entering the house
☐ Durability of the ceiling nets
☐ To beautify the house
☐ Household coverage
☐ Keep the room cool
☐ Others

Please specify.

Do you agree with the following potential negative sides of the ceiling net?

- ☐ It makes room too hot
☐ It reduces the storage space at the top of the wall
☐ Fixing looks untidy
☐ It is hard to clean
☐ Dirt/debris trapped by the ceiling net
☐ Rewiring of power lines
☐ Others

Please specify.

Other features in the ceiling net (if any).

Will you pay for the ceiling nets if you need to buy them in the future?

- ☐ Yes
☐ No

How much will you pay the maximum for ceiling nets for your household?

- ☐ 100 KSH
☐ 300 KSH
☐ 500 KSH
☐ 1000 KSH
☐ 2000 KSH
☐ 5000 KSH
☐ More than 10,000 KSH

How many mosquito nets does your household have?

How many new (unopened) mosquito nets does your household have?

Does anyone in your household wash the mosquito nets?

- ☐ Yes
☐ No

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How often does your household wash the mosquito nets?

☐ Every day

☐ Every week

☐ Every month

☐ less frequently than every month

How does your household wash the mosquito nets?

☐ With water

☐ With hot water

☐ With soap or detergent

☐ Others

How does your household dry the mosquito nets after washing it?

☐ Indoor

☐ Under the sunlight

☐ Under the shade

☐ Others

Have you ever gotten any instruction on how to use and treat the mosquito net?

☐ Yes

☐ No

From who did you get the instruction?

In general, how long can you use the bed net effectively?

☐ One year even without damages

☐ Three years even without damages

☐ Ten years even without damages

☐ Until it gets damaged

Do you agree the mosquito net contains some drugs against mosquitoes?

☐ Yes

☐ No

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Evaluation of the protective efficacy of Olyset®Plus ceiling nets for reduction of malaria incidence in children in Homa Bay County, Kenya: a cluster-randomized controlled study protocol

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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Infectious diseases, Public health
Keywords:	Malaria, Mosquito Vectors, Infection control < INFECTIOUS DISEASES



Title

Evaluation of the protective efficacy of Olyset®Plus ceiling nets for reduction of malaria incidence in children in Homa Bay County, Kenya: a cluster-randomized controlled study protocol

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Abstract

Introduction: Malaria is still a major health problem in sub-Saharan Africa, where 98% of global malaria mortality occurs. In addition, the spread of *Plasmodium falciparum* with partial artemisinin resistance in East Africa and beyond is a great concern. The establishment of more effective vector control, in addition to the current long-lasting insecticide-treated net (LLIN) distribution program, is an urgent task in these areas. One novel vector control candidate is the pyrethroid-PBO ceiling nets (Olyset®Plus ceiling nets) which can overcome the problems of variations in net use behaviors and metabolic resistance to insecticide in vectors. Our preliminary study suggests the protective efficacy and high acceptability of this tool. With this proposed second trial, we aim to evaluate the impact of this tool in a different eco-epidemiological setting in the lake endemic region of Kenya.

Methods: A cluster randomized controlled trial is designed to evaluate the impact of pyrethroid-PBO ceiling nets in Ndhiwa Sub-County, Homa Bay County, Kenya. A total of 44 clusters will be randomly assigned in a 1:1 ratio to the intervention group (pyrethroid-PBO ceiling nets) and the control group. The assignment will be accomplished through covariate-constrained randomization of clusters. For the primary outcome of clinical malaria incidence, 38 children from each cluster will be enrolled in a cohort and followed for 18 months. We will also evaluate the effects of the intervention on entomological indicators as well as its acceptance by communities and cost-effectiveness.

Ethics and dissemination: Ethics approvals were provided by the Mount Kenya University Institutional Scientific Ethics Review Committee and the Ethics Committee Osaka Metropolitan University. Study results will be shared with study participants and communities, the Homa Bay County Government and the Kenya National Malaria Control Programme. Results will also be disseminated through publications, conferences and workshops to help the development of novel malaria control strategies in other malaria-endemic countries.

Trial registration: UMIN000053873

Keywords

Malaria, *Anopheles* mosquito, vector control, Pyrethroid resistance, Ceiling net, Kenya, Cluster-randomized controlled trial

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Administrative information

Title {1}	Evaluation of the protective efficacy of Olyset®Plus ceiling net on reducing malaria incidence in children in the Great Lake Region, Kenya: study protocol for a cluster-randomized controlled trial
Trial registration {2a and 2b}.	UMIN000053873
Protocol version {3}	Version 6.0
Funding {4}	This work is supported by the Japan International Cooperation Agency (JICA) and Japan Agency for Medical Research and Development (AMED) under the Science and Technology Research Partnership for Sustainable Development Goals (SATREPS) program.
Author details {5a}	Osaka Metropolitan University, Japan Nagasaki University, Japan Tohoku University, Japan National Institute of Infectious Diseases, Japan Mount Kenya University, Kenya National Malaria Control Programme, Nairobi, Kenya Kenya National Bureau of Statistics, Nairobi, Kenya Kenya Medical Research Institute, Kenya Homa Bay County, Kenya Karolinska Institutet, Sweden

	Stockholm University, Sweden
Name and contact information for the trial sponsor {5b}	Department of Virology and Parasitology/Research Center for Infectious Diseases, Graduate School of Medicine, Osaka Metropolitan University (OMU), Japan 1-4-3, Asahimachi, Abeno, Osaka, Osaka, Japan, 545-8585 TEL: + 81-6-6645-3760 Website: https://ocuparasitology.com/en/ Directorate of Research and Innovation, Mount Kenya University (MKU), Kenya General Kago Road, Thika, Kiambu, Kenya Website: https://www.mku.ac.ke
Role of sponsor {5c}	OMU will support project management oversight, trial management, data management, statistical analysis, and research governance. MKU also holds overall authority together with project management and analysis.

Strength and limitations of this study

- This is a second cluster-randomized controlled trial of a novel vector control tool, pyrethroid-PBO ceiling net, to evaluate its efficacy in reducing malaria incidence among children.
- The implementation of monthly active screening within the prospective cohort population established in each cluster facilitates the assessment of infection incidence.
- The incorporation of multidisciplinary outcomes, encompassing social aspects and cost-effectiveness analyses, provides valuable insights for the potential future deployment of this intervention within integrated malaria control strategies.
- One of the anticipated limitations is the possible contamination between intervention and control clusters because we will not set a buffer zone due to the geographical proximity among clusters.

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6 101 **Introduction**
7
8 102 **Background and rationale {6a}**
9
10 103 Malaria is still a major health problem, particularly in sub-Saharan Africa, where 98% of global malaria
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12 104 mortality occurs [1]. Although the morbidity and mortality of malaria declined from the 2000s to 2015
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14 105 owing to many investments and interventions, such as long-lasting insecticide-treated nets (LLINs), malaria
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16 106 rapid diagnostic tests (RDTs), and artemisinin-based combination therapies (ACTs), progress has stalled
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18 107 since 2015. Moreover, the spread of *Plasmodium falciparum* partially resistant to ACT in Africa is an
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20 108 enormous concern. Currently five African countries, Rwanda [2], Uganda [3], Eritrea [4], Ethiopia [5], and
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22 109 the United Republic of Tanzania [6] have reported delayed clearance of *P. falciparum* after treatment with
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24 110 ACTs. Kenya's proximity to these countries highlights the urgent need to establish effective vector control,
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26 111 in addition to maintaining antimalarial drug efficacy and strengthening resistance surveillance.
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31 113 Among several vector control measures, LLIN is the most widely adopted tool to prevent mosquito bites and
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33 114 interrupt malaria transmission. However, suboptimal uses of LLIN are one of the key factors in reducing the
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35 115 impact of LLIN on the malaria burden, together with insufficient provision in the mass net distribution
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37 116 program or shortening durability of nets [7]. In the Lake Victoria basin, alternative uses of LLIN for fishing
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39 117 and protecting crops and chicks are well-known local behaviors [8,9] as reported in other endemic areas [10].
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41 118 In fact, in many areas including our study sites in Homa Bay County, Kenya, malaria prevalence remains
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43 119 high despite widespread distribution of LLINs and their periodic replacements for more than a decade. This
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45 120 suggests that LLIN alone is insufficient to interrupt malaria transmission in this region.
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50 122 Recently, we have proposed a novel vector control tool that covers the ceiling and the gap between the
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52 123 ceiling and the walls of residential structures with co-formulated pyrethroid and piperonyl butoxide (PBO)
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54 124 bed net material, called the Olyset®Plus (Sumitomo Chemical) ceiling net. The benefit of installing the
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56 125 pyrethroid-PBO ceiling net in addition to conventional LLINs is detailed elsewhere [11]. Briefly, the
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58 126 pyrethroid-PBO ceiling net provides a combination of physical and chemical protection against mosquitoes
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which seek human bloodmeal in the house. Recent reports have demonstrated that a substantial proportion of residual biting exposure occurs between the hours of entering indoor spaces and retiring to bed [12], pyrethroid-PBO ceiling nets may have a significant impact. Furthermore, the ceiling net is semi-permanently installed and requires no further action from end users, thus its protective efficacy is consistently extended to all who stay in the house and less affected by factors such as discomfort or sleeping arrangement that contribute to variations in conventional LLIN use [13]. The concept of ceiling net was previously investigated [14], and in this study, by integrating it with pyrethroid-PBO bed net material, this tool is anticipated to be effective even against pyrethroid-resistant mosquitoes, which are widely reported across Africa.

The aim of this study is to evaluate the efficacy, acceptability, and cost-effectiveness of pyrethroid-PBO ceiling nets on malaria morbidity and transmission in the Lake Victoria basin of Kenya. Preliminary data from our previous study on Mfangano Island in Lake Victoria [11] suggest a substantial reduction in malaria prevalence among school children and high community acceptance of this tool (unpublished data). With this proposed second trial, we aim to evaluate the impact of this tool in a different eco-epidemiological setting with relatively higher malaria transmission, more frequent human and vector movement, and synergistic impact from other interventions such as indoor residual spraying (IRS) and the RTS,S malaria vaccine. Since effective malaria controls need to be tailored to the local context, evidence of the effectiveness of pyrethroid-PBO ceiling nets from various transmission settings will increase the appeal of this intervention. Furthermore, considering the recent increase in choices of malaria control tools and the necessity of combining various tools to maximize the impact of the malaria control program, it is important to understand the acceptability and cost-effectiveness of each intervention to guide its future deployment.

To achieve these objectives, our collaboration with local institutions including the Kenya National Bureau of Statistics (KNBS), the National Malaria Control Programme (NMCP), the Kenya Medical Research Institute (KEMRI), and Homa Bay County, started from the research planning stage. This collaboration is crucial to the seamless transition from field trial to expanded implementation and policy development.

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Objectives {7}

The study has four research domains: epidemiology, entomology, social aspects, and cost-effectiveness.

For the epidemiology domain, the primary objective is to determine the protective efficacy of pyrethroid-PBO ceiling net in reducing malaria clinical incidence in children 6 months to 14 years old over 18 months post-intervention. This age range was selected to include both children under five years who are at high risk of malaria-related morbidity and mortality, and the school-age children who have the highest prevalence of *Plasmodium* infections[15]. The secondary objectives are (1) to determine the protective efficacy of pyrethroid-PBO ceiling nets in reducing *Plasmodium* infection prevalence by PCR in all age groups at 6-, 12-, and 18- months post-intervention; (2) to determine the spillover effects of pyrethroid-PBO ceiling nets in reducing *Plasmodium* infection prevalence in all age groups at 6-, 12-, and 18-months post-intervention; and (3) to determine the protective efficacy of pyrethroid-PBO ceiling net in reducing *Plasmodium* infection incidence in children 6 months to 14 years old over 18 months post-intervention.

For the entomology domain, the primary objective is to evaluate the impact of pyrethroid-PBO ceiling nets on the indoor mosquito density of the primary malaria vector species captured by CDC light traps. The secondary objectives are (1) to determine the impact of pyrethroid-PBO ceiling nets on the entomological inoculation rate (EIR) and (2) to determine the prevalence of voltage gated sodium channel (VGSC) mutations in vectors.

For the social aspects domain, the primary objective is to assess the determinants of social acceptability of the pyrethroid-PBO ceiling net in both the intervention and control arms. The secondary objectives are (1) to determine the feasibility of installing the pyrethroid-PBO ceiling nets and (2) to measure attitudes, emotions, knowledge, and beliefs relating to the ceiling net in Ndhiwa Sub-County.

For the cost-effectiveness domain, the primary objective is to determine the incremental cost effectiveness ratios (ICERs) of adding the pyrethroid-PBO ceiling net to existing malaria control interventions under field

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trial conditions. The secondary objectives are (1) to establish the relative contribution to costs of the distinct programmatic elements and identify the inputs that contribute the most to overall costs, and (2) to estimate the potential cost of providing pyrethroid-PBO ceiling net at a larger scale over 3 and 5 years under operational scenarios.

Trial design {8}

The study is an open-label, cluster-randomized controlled trial (CRCT) with 44 clusters evenly divided between the intervention and the control arms. Each cluster will include one or two villages and consist of at least 50 households. A baseline survey will be conducted to determine the pre-intervention *Plasmodium* prevalence and *Anopheles* density, and to collect demographic and socioeconomic data for covariate-constrained randomization of clusters. The baseline survey will be conducted one month before cluster randomization. The post-intervention follow-up period will be 18 months. For the evaluation of the primary objective, 38 children aged 6 months to 14 years from each cluster will be recruited and followed for 18 months as a cohort. Cross-sectional surveys will be conducted after 6, 12, and 18 months of the intervention targeting 50 individuals of all ages from each cluster to estimate the overall *Plasmodium* prevalence.

Methods: Participants, interventions and outcomes

Study setting {9}

Location and administrative structure

Ndhiwa (713.5 km²) is one of nine sub-counties in Homa Bay County in Kenya. The sub-county has seven administrative wards: Kanyamwa Kologi, Kanyamwa Kosewa, Kabuoch North, Kwabwai, Kanyadoto, Kanikela, and Kabuoch South/Pala. Based on the number of malaria cases reported in the Kenya Health Information System (KHIS), the accessibility of the site, and population size, we selected Kanyamwa Kologi Ward as the target area (Figure 1). Agriculture is the primary economic activity, with sugarcane as a main commercial crop. County residents also keep animals such as dairy cattle, beef cattle, sheep, goats, and poultry [16]. The ward experiences a long rainy season from March to June and a short rainy season from October to December. As of 2019, the average monthly precipitation is 228.64 mm and the mean annual temperature is 26.7°C. The relative humidity remains elevated year-round, fluctuating between 75% to 85%

[17].

211

212 *Demographics*

213 The population of Kanyamwa Kologi Ward is approximately 33,000 according to the 2019 national census

214 [18]. The dominant ethnic group in the region is Luo and the primary languages are DhoLuo, Kiswahili, and

215 English. There are 172 primary and 36 secondary schools in Ndhiwa Sub-County [19]. Within Kanyamwa

216 Kologi Ward, there are 28 primary and 7 secondary schools.

217

218 *Malaria epidemiology and control measures*

219 Based on the KHIS, there were 429.1 and 457.2 confirmed malaria cases per 1,000 population in Ndhiwa

220 Sub-County and Kanyamwa Kologi Ward, respectively, in 2023. The primary malaria vector in the sub-

221 county is *Anopheles funestus*, which prefers feeding on humans. Although *An. arabiensis* exhibits

222 predominantly zoophilic behavior, it is also a significant malaria vector in our study area [20]. In Homa Bay

223 County, LLINs have been distributed every three years since the early 2000s, and IRS and the RTS,S malaria

224 vaccine have been piloted in several areas since 2018 and 2019, respectively [21]. Notably PBO-

225 incorporated LLINs (Veeralin®LN, manufactured by VKA Polymers, Tamil Nadu, India) were distributed in

226 late 2023. In Kanyamwa Kologi Ward, there is one level four hospital and seven health centers.

227

228 **Eligibility criteria {10}**

229 As the ceiling nets are installed per structure, we set the inclusion criteria on a structural basis. The inclusion

230 criteria for the installation of the ceiling nets are (1) residential structures with at least one permanent

231 resident aged 18 years or older in the household, (2) informed consent provided by a resident in the

232 household, and (3) house structure amenable to ceiling net installation in terms of size of the structure,

233 presence of eave, ceiling board, and vertical beams, and material of the top part of the wall. The applicability

234 of the ceiling net installation will be assessed by experienced field staff. The exclusion criteria are (1) vacant

235 structure, confirmed by at least two visits by community health promoters (CHPs), (2) dwelling structure to

236 be vacated or destroyed within the study period, (3) non-eligible house structure for the ceiling net

237 installation, and (4) non-residential structures (school, shop, kitchen, storage, and toilet). The inclusion

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criteria for the prospective cohort are (1) children aged 6 months to 12 years old at the time of enrolment, (2) living in the study area at the time of pyrethroid-PBO ceiling net installation, (3) having no plan to leave or stay outside the study area for an extended period (longer than one month) over the 18-month follow-up period, and (4) informed consent provided by the participants or the parent or legal guardian. The exclusion criterion is having severe chronic illnesses. The inclusion criteria for cross-sectional malaria surveys for all age groups are (1) living in the study area during the study period, and (2) informed consent being provided by the participants or the parent or legal guardian before each survey. The exclusion criteria are (1) having severe chronic illnesses and (2) pregnancy known at the time of the surveys.

Who will take informed consent? {26a}

Written informed consent will be obtained by the study team members who fully understand the study protocol. After eligibility is confirmed, the study team members will present to the potential participant a document containing all relevant information about the study in Luo and English. If the participant cannot read, study information will be conveyed verbally in Luo, Kiswahili, and/or English by the study team members. The potential participant will have opportunities to ask any questions. Agreement to participate will be sought only after the participant indicates complete understanding of the study.

Additional consent provisions for collection and use of participant data and biological specimens {26b}

The study information document for ceiling net installation contains the study overview. In addition, the documents for cross-sectional and cohort surveys contain details on collecting, storing, and using personal data and biological specimens during the study.

Interventions

Explanation for the choice of comparators {6b}

In Kenya, LLIN is the most widely used malaria preventive measure. The Division of National Malaria Programme coordinates free LLIN distribution, and the county governments deliver LLINs to residents in all endemic counties every three years. In Homa Bay County, the RTS,S malaria vaccine has been implemented since 2019. The primary purpose of this trial is to demonstrate the superiority in malaria prevention of

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2
3 266 adding pyrethroid-PBO ceiling nets to the standard malaria control program. Thus, in the control arm, no
4
5 267 pyrethroid-PBO ceiling nets will be installed, but LLIN use and RTS,S immunization will be allowed in the
6
7 268 control and intervention arms as the current best practice. There is no plan for new LLIN distribution during
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9
10 269 the study period.

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12 270
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14 271 **Intervention description {11a}**

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16 272 In the intervention arm, pyrethroid-PBO ceiling nets will be installed in all dwelling units where residents
17
18 273 sleep, free of charge to the households. All participants will be encouraged to continue to use LLINs,
19
20 274 distributed by the Homa Bay County government. In each intervention cluster, 1 CHP and 2 community
21
22 275 volunteers will be recruited from the intervention cluster and another 1 CHP from the control cluster will
23
24 276 join the team to enable future knowledge dissemination. The net installation team will be trained to install
25
26 277 ceiling nets by skilled local research assistants who participated in previous trials. The head (or another
27
28 278 adult) of the household eligible to a ceiling net will be notified at least 24 hours before the scheduled
29
30 279 installation time. The cost of the ceiling nets and their installation will be covered by the research team.
31
32 280 Details of the installation procedure are described in the previous study protocol [11]. Briefly, the ceiling net
33
34 281 is a rectangular sheet of pyrethroid-PBO net with loops sewn along the diagonal seams. The loops are roped
35
36 282 to the support beams under the roof and the edges of the net are stapled to the wall.
37
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39 283

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41 284 **Criteria for discontinuing or modifying allocated interventions {11b}**

42
43 285 As the ceiling net is semi-permanently installed, the intervention will only be discontinued if the participant
44
45 286 specifically requests the removal of the ceiling net by the study team. There will be no crossover from the
46
47 287 control arm to the intervention arm during the follow-up period. Those who migrate between the arms or
48
49 288 emigrate from the study areas will be dropped from the study follow-up.
50
51
52 289

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54 290 **Strategies to improve adherence to interventions {11c}**

55
56 291 Adherence to the intervention cohort in this study is defined as sleeping in houses with pyrethroid-PBO
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58 292 ceiling nets. Adherence is monitored indirectly by assessing the number of nights each participant spends
59
60 293 outside their house during the monthly interview. During each house visit, CHPs will visually inspect the

condition of the ceiling nets. Any visible tear and damage to the ceiling net will be reported to the research team, who will assess the size and location of the damage and perform repair or replace the ceiling net if necessary.

Relevant concomitant care permitted or prohibited during the trial {11d}

There is no specific concomitant care prohibited during the trial. All participants in both arms will continue to receive and use free LLIN and have access to standard medical care, including malaria testing by RDT, treatment with ACT and RTS,S malaria vaccination.

Provisions for post-trial care {30}

All participants will be under the normal healthcare system in the study setting. No perceived health risks for the intended population are expected with the intervention. To monitor the long-term impact of the intervention, the research team may conduct additional cross-sectional surveys 2 and 3 years post-intervention to monitor further parasite transmission in the population.

Outcomes {12}

Epidemiological domain: The primary outcome will be symptomatic malaria case incidence, defined as axillary temperature of $\geq 37.5^{\circ}\text{C}$ or a history of fever in the preceding 48 hours, and positive RDT, in children aged 6 months to 14 years enrolled in the cohort, monitored with a monthly visit and passive case detection in the health facilities during an 18-month follow-up. The secondary outcomes will be (1) the prevalence of *Plasmodium* infections by PCR in all age groups at 6, 12, and 18 months post-intervention and (2) infection incidence by PCR in the prospective cohort of children aged 6 months to 14 years over 18 months.

Entomological domain: The primary outcome will be the density of the primary malaria vectors, species composition and sporozoite infection rates. Indoor malaria vector density will be determined using CDC light trap, and species composition and sporozoite infection rates will be determined by microscopy and PCR. The secondary outcomes of the entomology domains will be (1) changes in EIR as a measure of

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2
3 322 malaria transmission and (2) prevalence of VGSC mutations associated with insecticide resistance in
4
5 323 *Anopheles* mosquitoes captured by light trap.
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7 324
8
9 325 Social aspect domain: The primary outcome will be the percentage of households consenting to pyrethroid-
10 326 PBO ceiling net installation when offered. In addition, we will include observations and discussions about
11 326
12 327 individual attitudes toward the ceiling net. The secondary outcomes of the social aspect domain will be the
13 327
14 328 percentage of the intact ceiling net, description of damaged net, and the impact on the living environment
15 328
16 329 such as perceived temperature in the house, dirt/debris trapped by the ceiling net, loss of storage space at the
17 329
18 330 top of the wall, and rewiring of power lines. They will be evaluated by questionnaires at 6, 12, and 18
19 330
20 331 months post-intervention.
21 331
22 332
23 332
24 333 Cost-effectiveness domain: The primary outcome will be the incremental cost-effectiveness of adding
25 333
26 334 pyrethroid-PBO ceiling net to existing malaria control interventions under field trial conditions from the
27 334
28 335 societal and provider perspectives. The secondary outcomes of the cost-effectiveness domains will be (1) the
29 335
30 336 costs of the distinct programmatic elements and the inputs that contribute the most to overall costs, and (2)
31 336
32 337 the cost of providing pyrethroid-PBO ceiling net at a larger scale over three and five years under operational
33 337
34 338 scenarios.
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36 339
37 339
38 340
39 340 **Participant timeline {13}**
40 340
41 341 The schedule of trial activities is presented in Figure 2. The detail of each survey is described in Figure 3.
42 341
43 342
44 342
45 343
46 343 **Sample size {14}**
47 343
48 344 The sample size was calculated using the method of Hayes and Moulton [22]. All sample sizes will be
49 344
50 345 recalculated based on the baseline data, which will be collected about one month before the ceiling net
51 345
52 346 installation.
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54 347
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56 348
57 348 *Epidemiological survey*
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The following calculations were based on the historical data collected from the Lake Victoria region in Kenya with a clinical malaria incidence rate of 0.5 per person-year in children under 14 years old by RDT (unpublished data on Mfangano island), 40% parasite prevalence for all age groups by PCR and a between-cluster coefficient of variation (CV) in incidence rate of 0.24 in both groups. In the study site, RTS,S malaria vaccination began in 2019, with a mass distribution of PBO-incorporated LLINs at the end of 2023. Therefore, the intervention effect is expected to be smaller than those in previous studies and is conservatively assumed to be 25%. Assuming 38 individuals per cluster to be followed for up to 18 months with 20 % loss-to-follow up rate, we require 22 clusters per arm, a total of 1,672 children, to achieve 80% power to detect a significant incidence rate ratio of 0.75 (25% protective efficacy) at a two-sided type 1 error of 5%. With 50 individuals per cluster (2,200 total individuals) for the secondary outcome of *Plasmodium* prevalence by PCR in all age groups, we would achieve 5% type 1 error and 80% power to detect 23.5 % relative reduction. We do not specify the sample size for identifying spillover effects because spillovers tend to have smaller effect sizes relative to total or overall effects, so typically larger sample sizes are required to detect them. Although our study may be underpowered to detect spillovers, we will report the results as an exploratory analysis.

Entomological survey

Based on the previous entomological study conducted in Homa Bay County, we assume a mean vector density (number of mosquitoes per CDC light traps) of 3.3, a standard deviation (SD) of 0.634, and CV of 0.192 [14]. For 80% power to detect a 50% decrease in mean mosquito densities at 5% type 1 error level, we need to capture mosquitoes from five houses in each of 44 clusters.

Recruitment {15}

Thirty-eight eligible children in each cluster will be randomly recruited into our cohort. Recruitment will be limited to children aged 12 or younger, to avoid children aging out during the 18-month monitoring period. Study team staff will obtain informed consent from the parents or caregivers of the children before enrolling the children in the cohort. For the cross-sectional survey at each time point, we will randomly select from each cluster 50 individuals of all age groups. To guarantee the representativeness for all age groups, the

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2
3 377 selection will be done with following age category stratifications; 0-4, 5-9, 10-14, 15-19, and 20 and above.
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5 378

7 379 **Assignment of interventions: allocation**

9 380 **Sequence generation {16a}**

12 381 Random numbers will be generated using the sample function in R software.
13
14 382

16 383 **Concealment mechanism {16b}**

19 384 The individual, household, and villages (clusters) are all given unique IDs at the beginning of the baseline.
20
21 385 Any following steps handle only these anonymized IDs.
22
23 386

25 387 **Implementation {16c}**

27 388 After the baseline survey, covariate-constrained randomization will be used to allocate the 44 clusters across
28
29 389 the two study arms. The following factors will be constrained: baseline malaria infection prevalence by RDT
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31 390 in children aged 0.5–14 years, LLIN usage, malaria vaccine coverage, socioeconomic status (SES),
32
33 391 population size, the proportion of eligible houses for the ceiling net installation, and vector densities. An
34
35 392 independent statistician will perform the randomization. Local study assistants will perform participant
36
37 393 enrollment.
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40 394

42 395 **Assignment of interventions: Blinding**

45 396 **Who will be blinded {17a}**

47 397 Due to the visibility of the pyrethroid-PBO ceiling net, neither the trial participants nor the members of the
48
49 398 study team who take part in field activities can be blinded. However, laboratory- and office-based personnel
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51 399 (e.g., microscopists, laboratory technicians, and data analysts) will be blinded to the identity and intervention
52
53 400 status of the trial participants since all biological specimens will be identified by a unique numeric study
54
55 401 identifier, and personal information will be removed before analyses.
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58 402

60 403 **Procedure for unblinding if needed {17b}**

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This is an open-label trial, and only the data measurers are blinded. Therefore, there is no circumstance that they need to be unblinded.

Data collection and management

Questionnaires for the baseline survey, cohort surveys, and post-intervention cross-sectional surveys are provided in the supplementary file.

Plans for assessment and collection of outcomes {18a}

Census and baseline cross-sectional survey

In Kanyamwa Kologi Ward, 85 census enumeration areas (EAs) are defined by the 2019 Kenya Population and Housing Census. Births, deaths, and migrations in each EA are regularly updated by CHPs using the integrated community health system maintained by the Ministry of Health. Fifty EAs are randomly selected for our baseline survey, during which demographic information of all individuals is updated. To ensure balanced cluster allocation, the baseline survey includes a questionnaire for all households, RDT testing of all children aged 6 months to 14 years, and an entomological survey of randomly sampled households. We modified the questionnaire used in the 2020 Kenya Malaria Indicator Survey (KMIS) mainly to quantify the SES of each household and bed net usage. In addition, we add questions to quantify the favorability of ceiling nets before the intervention.

Cohort monitoring

Incidence of clinical malaria in the prospective cohort will be estimated by both active and passive case detections. For active case detection, we will conduct home visits every four weeks. From all cohort participants, axillary temperature will be measured using a digital thermometer, and *Plasmodium* infection status will be determined by RDT and PCR. Participants with fever ($>37.5^{\circ}\text{C}$) or other malaria-related symptoms listed in the Kenya National Malaria Treatment Guideline at the time of home visit or within the previous 48 hours will be tested for malaria by RDT. History of travel, confirmed malaria episode, and visit to local health facilities since the previous visit is recorded. For passive case detection, we ask all cohort participants to visit designated health facilities in case they suspect malaria between home visits. The

1
2
3 432 designated facilities are asked to record all malaria tests performed regardless of their results together with
4
5 433 the cohort ID. The cost of RDT and anti-malarial treatment will be covered by the research team to
6
7 434 encourage cohort participants to use only designated facilities.
8
9 435
10
11 436 *Cross-sectional malariometric surveys*
12
13
14 437 Malaria prevalence in children and adults will be estimated using cross-sectional malariometric surveys in
15
16 438 communities. These surveys will be conducted at 6, 12, and 18 months post-installation. Community surveys
17
18 439 will be conducted by house visits.
19
20 440 *Plasmodium* infection status will be determined using three methods: RDT, microscopy, and PCR. A finger-
21
22 441 prick blood sample will be collected for on-site diagnosis using the Bioline Malaria Ag P.f/Pan RDT (Abbott
23
24 442 Diagnostics Korea Inc., Republic of Korea). Survey participants with positive test results will be provided
25
26 443 with a treatment course of artemether-lumefantrine with dosing instructions in accordance with guidelines
27
28 444 from the Ministry of Health in Kenya after checking their recent treatment history. Blood smears will be
29
30 445 prepared on site and transported to the main laboratory in Homa Bay where thin smears are fixed with
31
32 446 methanol and all smears are stained with 3% Giemsa solution for 30 minutes, then examined by experienced
33
34 447 microscopists. Two blood samples (70 µl each) will be collected with a 75-mm heparinized micro-hematocrit
35
36 448 capillary tube (Thermo Fisher Scientific, MA, USA) and spotted on Whatman ET31 Chr filter paper
37
38 449 (Whatman International. Maidstone, UK). The blood samples will be allowed to dry at ambient temperature
39
40 450 and stored in individual zipped plastic bags at -20°C. The dried blood spots will be used for the determination
41
42 451 of malaria status by PCR [23].
43
44 452
45
46 453 *Entomological surveys*
47
48
49 454 Indoor mosquitoes will be collected from five randomly selected houses within each cluster using the CDC
50
51 455 light trap method. Samples will be preserved in 96% ethanol and placed in a cool box with ice. Specimens
52
53 456 will be examined for sex determination by microscopy and species identification by microscopy and PCR.
54
55
56 457 Indoor mosquitoes will be collected at baseline, 6, 12 and 18 months post ceiling net installation.
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58 458
59
60 459 *Social aspects*

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We will conduct an exploratory sequential research design using integrated mixed methods (qualitative and quantitative). Qualitative assessment of community perceptions on the pyrethroid-PBO ceiling nets, community facilitators, and concerns of pyrethroid-PBO ceiling net use will be implemented, followed by quantitative assessments every 6 months and routine monitoring to evaluate the durability of pyrethroid-PBO ceiling nets using observation checklists in randomly sampled houses. At the end of the study, other qualitative case studies, such as focus group discussions and key informant interviews, will be conducted to document any remarks related to the study and inform the sustainability and scalability of the intervention.

Cost-effectiveness analysis

Incremental financial and economic cost data of pyrethroid-PBO ceiling net will be collected alongside the intervention. In cases where resources, such as staff, are shared among multiple elements, the allocation of costs will be carried out using an appropriate proxy. Costs related to research activities will be excluded from this allocation. Financial costs will be derived from project expenditure records, while economic costs, which encompass financial expenditures and donated resources, will be identified through project records and social aspects activities. The value of donated resources will be credited based on prevailing market rates. Furthermore, capital costs will be annualized over their useful life for financial costing and annualized at a discount rate of 3% for economic costing.

Plans to promote participant retention and complete follow-up {18b}

All surveys planned for the epidemiological and entomological domains will be conducted by house visits. CHPs will make an appointment with eligible participants before each visit to confirm the participants' available date and time. Small remunerations will be provided to survey participants to compensate for their time. CHPs will receive detailed instructions and participatory training for all field procedures and will be actively supervised by the research team throughout the duration of the study. Feedback will be regularly sought from CHPs regarding any issues raised by study participants, and discussions will be held to resolve issues from the field.

Data management {19}

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2
3 488 All data from the baseline, cohort, and cross-sectional surveys will be captured using the Research Electronic
4
5 489 Data Capture (REDCap) software on electronic tablets. Data will be uploaded daily to a highly secure server
6
7 490 hosted by Mount Kenya University (MKU). All data from the quantitative surveys will also be stored
8
9 491 securely and backed up regularly to prevent data loss. Data access and management of databases will be
10
11 492 limited to authorized study investigators and collaborators. After validation of data uploaded to the MKU
12
13 493 server, data stored locally on the tablet computers will be permanently deleted to minimize unauthorized
14
15 494 access.

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18 495
19
20 496 **Confidentiality {27}**

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22 497 To maintain confidentiality, each participant in cross-sectional surveys, the longitudinal cohort, and the
23
24 498 quantitative surveys is assigned a unique identifier. The data collected will be labelled using the unique
25
26 499 identifier and stored separately from the key linking personal information (name, date of birth, GPS of each
27
28 500 household, and phone number). The data will be kept on a secure server that is only accessible to the
29
30 501 research staff. Publications will contain only aggregated data, and no personal information will be included.

31
32 502
33
34
35 503 **Plans for collection, laboratory evaluation and storage of biological specimens for genetic or molecular**
36
37 504 **analysis in this trial/future use {33}**

38
39 505 Anonymized blood samples from study participants will be stored and analyzed for *Plasmodium* infections
40
41 506 by microscopy and PCR in our laboratory in Homa Bay. Microscopic examinations of adult mosquito
42
43 507 specimens will be conducted in our field laboratory in Mbita, while PCR analyses will be conducted in our
44
45 508 laboratories in Homa Bay and MKU. Laboratory data outputs will be entered in Microsoft Excel and
46
47 509 imported into the database. No human genetic analysis is planned for this study. However, remaining
48
49 510 biological materials will be stored indefinitely for future studies unless the participants opt out during the
50
51 511 informed consent process. Participants are provided with contact information of the research team and can
52
53 512 remove themselves from this study or any future studies at any time without penalty or prejudice.

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55 513
56
57 514 **Statistical methods**

58 514
59
60 515 **Statistical methods for primary and secondary outcomes {20a}**

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We will follow the CONSORT guidelines extended for CRCT for statistical analysis and result reporting.

The intention-to-treat (ITT) analysis is the primary analysis approach for both the primary and secondary objectives for the epidemiological and entomological studies. The per-protocol (PP) analysis is included as a supplementary analysis for the primary and secondary objectives for the epidemiological and entomological studies. Detailed methodologies for the epidemiological part are described in the supplementary file of statistical analysis plan.

Clinical malaria incidence

We will determine the protective efficacy of pyrethroid-PBO ceiling nets against malaria case incidence by comparing clinical malaria incidence rates between arms. We will use mixed effects negative binomial regression accounting for within-cluster correlation of outcomes. Possible confounding factors such as age, sex, bed net usage, house structure, malaria vaccination history, and SES will be adjusted as well as covariates used in the covariate-constrained randomization. In addition, because we will not set a buffer zone, the distance to the nearest household in the other arm will be adjusted in the following analysis to reduce the contamination between two arms. The variable was selected from the previous study [24].

Prevalence of malaria infection

The secondary outcome, the prevalence of malaria infection by PCR and microscopy measured at 6, 12, and 18 months after the ceiling net installation will be analyzed using mixed effects logistic regression adjusting for the above-mentioned confounding factors.

Exploratory analysis for spillover effects

Evidence for positive spillover effects of the ceiling net on malaria infection prevalence in all age groups will be assessed by comparing individuals with no intervention conditioning 1) the distance to the nearest ceiling net installed household, and 2) the coverage of surrounding households with ceiling net within 400 m. The distance of 400 m was chosen as the spillover effect appears to attenuate at this distance based on previous reports [25].

1
2
3 544 *Entomology*
4
5 545 Differences in vector density and EIR between arms will be evaluated by random effects negative binomial
6
7 546 regression taking into account the intracluster correlation.
8

9 547
10
11 548 *Social aspects*
12
13 549 We will employ the Framework for Reporting Adaptations and Modifications to Evidence-based
14
15 550 Implementation Strategies (FRAME-IS) [26] to document the implementation processes of the ceiling nets,
16
17 551 and the evidence integration triangle framework [27] to align the evidence generated to policy and vector
18
19 552 control strategies from the health systems aspect. The theoretical framework in qualitative research will be
20
21 553 grounded theory [28]. Data from ethnographic, focus group discussions, key informant interview will be
22
23 554 summarized using content thematic analysis. Pre- and post-intervention acceptability to install pyrethroid-
24
25 555 PBO ceiling net intervention will be compared to actual consent using logistic regressions.
26
27 556

28
29 557 *Cost-effectiveness*
30
31 558 The economic and financial costs associated with the pyrethroid-PBO ceiling net intervention will be
32
33 559 presented in total and disaggregated forms, highlighting the relative contribution of each program element to
34
35 560 the overall program costs. To facilitate comparisons with other malaria vector control interventions, the
36
37 561 costs will be converted into cost per household and per person receiving the intervention annually. Various
38
39 562 program scenarios, such as different scales and durations, will be presented to estimate operational
40
41 563 implementation costs. Compared to the control group, we will utilize the number of malaria cases averted in
42
43 564 the pyrethroid-PBO ceiling net arm to calculate the DALYs averted using standard methods.
44
45 565

46
47 566 **Interim analyses {21b}**
48
49 567 No interim analysis is planned because neither the insecticide permethrin nor the synergist PBO as
50
51 568 formulated in pyrethroid-PBO LLINs is known to pose significant health and safety risks [11,14].
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53 569

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55 570 **Methods for additional analyses (e.g. subgroup analyses) {20b}**
56
57 571 We will perform the same analysis for three age subgroups (≤ 59 months old; 5 years old to 14 years old; 15

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years old or older) to examine if the effects of pyrethroid-PBO ceiling net differ by age groups. In addition, we plan to use other machine learning methods to estimate the conditional average treatment effect (CATE), such as causal forests—which extend random forest algorithms for causal inference [29]—and the super learner algorithm, an ensemble method that combines multiple predictive models to improve accuracy [30].

Methods in analysis to handle protocol non-adherence and any statistical methods to handle missing data {20c}

In the cohort, non-adherence to the intervention can be identified by monthly interviews. Participants who regularly sleep outside their homes will be removed from the analyses. The extent and patterns of missing data will be assessed once all data collection has been completed. If necessary, we will apply simple hot-deck imputation methods if the missing fraction for the covariate is $<5\%$ or appropriate multiple imputation approaches if the missing fraction for a covariable are $\geq 5\%$. If a non-ignorable portion of the subjects have missing values on a covariate (due to missing at random or missing completely at random), that covariate may be excluded in the model.

Plans to give access to the full protocol, participant level-data and statistical code {31c}

This manuscript is the full protocol. The corresponding author will make the de-identified datasets or any future statistical code available upon reasonable request.

Oversight and monitoring

Composition of the coordinating centre and trial steering committee {5d}

The sampling team, composed of CHPs and laboratory technicians, set up a day-to-day communication group and exchanged their experiences. A local management team of study investigators from Kenya and Japan also joined this, leading and advising the activities and monitoring the sample and data integrity. A monthly meeting will be held by the steering committee composed of all key researchers from Kenya and Japan, including the principal investigator (PI) and co-PI, to monitor the progress of the trial.

Composition of the data monitoring committee, its role and reporting structure {21a}

1
2
3 600 Our intervention is considered to be of a low-risk nature. The data safety monitoring committee will consist
4
5 601 of two medical doctors who are independent from the project organizations and sponsor and have no
6
7 602 competing interests. The primary responsibilities of this committee will be to periodically review self-
8
9 603 reported adverse events derived from the monthly questionnaire in the cohort. All severe adverse events
10
11 604 observed or reported during the study will be reported to the committee in a timely manner, and the
12
13 605 committee will determine the relationship between the severe adverse events and the intervention. For
14
15 606 additional credibility about study quality, the researchers will consult a third statistician, if necessary.
16
17
18 607
19

20 608 **Adverse event reporting and harms {22}**

21
22 609 In addition to the safety monitoring committee, researchers will compare self-reported non-serious adverse
23
24 610 events such as coughs, rashes, and itches between the intervention and the control arms in the cohort and
25
26 611 cross-sectional surveys. In the event of a study-related serious adverse event, the study team will convene a
27
28 612 meeting immediately with the MOH and Homa Bay County Teaching and Referral Hospital representatives
29
30 613 to review the case and take necessary action.
31
32
33 614

34
35 615 **Frequency and plans for auditing trial conduct {23}**

36
37 616 A monthly meeting will be held during the follow-up period to ensure that all surveys and investigations are
38
39 617 conducted according to the study protocol. The study is required to submit annual reports and renewal to
40
41 618 ethical review boards of Osaka Metropolitan University, Japan, and Mount Kenya University, Kenya.
42
43 619
44

45 620 **Plans for communicating important protocol amendments to relevant parties (e.g. trial participants,**
46
47 621 **ethical committees) {25}**

48
49 622 Decisions on important trial amendments must be made through a formal procedure and will be approved by
50
51 623 institutional review boards (IRB) at Mount Kenya University and Osaka Metropolitan University. The
52
53 624 protocol in the clinical trials registry will also be updated accordingly.
54
55
56 625
57

58 626 **Dissemination plans {31a}**

59
60 627 Study results will be shared with the study participants and communities, the Homa Bay County Government

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and the Kenya National Malaria Control Programme. Results will also be disseminated through publications, conferences and workshops to help the development of novel malaria control strategies in other malaria-endemic countries. Suggestions from the participants will also help shape the future improvement of the intervention.

Discussion

Global malaria progress has flatlined in recent years: targets of reductions in malaria morbidity and mortality and required funding by 2030 are all off track as of 2023[6]. In addition, *P. falciparum* with partial artemisinin resistance, which has been a problem in the Great Mekong Subregion (GMS) for more than a decade, is emerging independently in sub-Saharan Africa [2–6,31]. Novel interventions that are cost-effective and widely accepted by local communities are urgently needed to contain the spread of artemisinin-resistant *P. falciparum* in sub-Saharan Africa.

Early results from our cluster randomized controlled trial of pyrethroid-PBO ceiling nets on Mfangano Island in Lake Victoria, Kenya suggest that ceiling nets can reduce *Plasmodium* prevalence and are positively received by the local communities. Nevertheless, there are regional differences in housing design, vector abundance and composition, and availability of malaria control interventions. As such the feasibility and acceptability of the ceiling net intervention are likely to depend on local eco-epidemiological context [32]. Furthermore, one of the secondary objectives in this study is to measure the spillover effects, i.e. how much a household that does not have a ceiling net benefits from living near a house with a ceiling net. This enables a broader understanding of the impact of the ceiling nets at the community level.

This trial has several limitations. First, although the study is designed as a cluster-randomized controlled trial, contamination between intervention and control clusters cannot be excluded, as buffer zones between intervention and control clusters cannot be created due to geographic proximity of houses and villages in the ward. A recent study, however, has shown that the spillover effect of interventions on malaria can extend to 3 km [33], so buffer zones of a few hundred meters, as set out in many studies, may not be sufficient. We will try to eliminate such contamination effects by integrating spatial data into our statistical model. Second,

1
2
3 656 because of the visible nature of the ceiling net, we cannot exclude open-label and observer biases. It is
4
5 657 conceivable that participants receiving ceiling nets may reduce their usage of conventional LLIN, as both
6
7 658 interventions are made of the same materials and may be perceived to protect against malaria in the same
8
9 659 manner. We aim to reduce such bias as much as possible through repeated reminders by CHPs that ceiling
10
11 660 nets serve as an addition to and not a replacement of conventional LLINs. We will conduct surveys and in-
12
13 661 depth interviews to elicit participants' perceptions of the ceiling net, which can guide future messaging and
14
15 662 implementation. To reduce observer bias, laboratory investigators and data analysts will be blinded. Third, in
16
17
18 663 the study area, pyrethroid+PBO-incorporated LLINs were distributed in 2023. It may reduce the effect of our
19
20 664 ceiling net intervention because pyrethroid+PBO-incorporated LLINs are more effective than non-PBO-
21
22 665 incorporated LLINs by targeting both *Anopheles* vectors with and without metabolic resistance to
23
24 666 pyrethroids. Pyrethroid+PBO incorporated LLINs received a conditional endorsement from the World
25
26 667 Health Organization (WHO) in 2017, and approximately half of the LLINs distributed in sub-Saharan Africa
27
28 668 in 2022 were of this type [6]. Given the abundance of PBO-incorporated LLINs in the region, it is important
29
30 669 to assess the effectiveness of the pyrethroid-PBO ceiling net as an addition to these LLINs to inform policy
31
32 670 recommendations. Recently LLINs combining two different classes of insecticides have been shown to be
33
34
35 671 superior to pyrethroid-based LLINs [34]. When these new LLINs become widely available, the effectiveness
36
37 672 of pyrethroid-PBO ceiling nets needs to be re-investigated.
38

39 673
40
41 674 **Trial status**

42
43 675 The Baseline survey was started on April 8, 2024. The recruitment of the intervention participants and the
44
45 676 ceiling net installation were conducted in June 2024. The current protocol is version 6.0 as of November 11,
46
47 677 2024.
48

49 678
50
51 679 **Abbreviations**

52
53 680 ACT: artemisinin-based combination therapy
54
55
56 681 CHP: community health promoter
57
58 682 CRCT: cluster-randomized controlled trial
59
60

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CV: coefficient of variation

KHIS: Kenya Health Information System

ITN: insecticide treated nets

IRS: indoor residual spraying

LLIN: long-lasting insecticidal nets

MKU: Mount Kenya University

PBO: piperonyl butoxide

RDT: rapid diagnosis tests

VGSC: Voltage gated sodium channel

Declarations

Acknowledgements

We would like to express our sincere gratitude to this study's participants, field, and laboratory staff. In addition, we acknowledge the collaboration and support of health offices in Homa Bay County, Kenya.

Authors' contributions {31b}

AK and JG are co-principal investigators. AK is the guarantor. YKK, WK, and AK developed the original concept. All authors discussed and contributed to the study protocol. YKK, WK, PO, KBM, JK, VO, JO, SMM, KNBS, KK, ES, GO, and AK contributed the preparation of the baseline survey. YKK, WK, PO, BM, TO, CWC, JK, SM, and MK drafted the manuscript. YKK, WK, CWC, MK, GO, and JG contributed to the revisions of the draft of the manuscript. DY participated as a senior statistician. YKK and MK drafted the statistical analysis plan (SAP) and WK, CWC, and DY revised. The authors read and approved the final manuscript and SAP.

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1
2
3 710 Chemical Corporation. The funding bodies play no role in the study design, data collection, analysis,
4
5 711 interpretation, and publication.
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9
10 713 **Availability of data and materials {29}**

11 714 The study regimes, consent forms, assent forms, and study-related materials are accessible from the
12
13
14 715 corresponding author. The final trial dataset will be available to all investigators. The corresponding author
15
16 716 will make the de-identified datasets and source codes for all analysis available upon reasonable request.
17

18 717
19
20 718 **Patient and public involvement**

21
22 719 Although the study design was developed through discussions among the researchers, consultations with the
23
24 720 local population were conducted prior to initiating the baseline survey, and their input was incorporated into
25
26 721 the study. Community involvement will also be ongoing during the implementation of interventions and
27
28 722 research activities.
29

30 723
31
32
33 724 **Ethics approval and consent to participate {24}**

34
35 725 Ethics approvals were received from Mount Kenya University Institutional Scientific Ethics Review
36
37 726 Committee (MKU-ISERC) (approval number: 2565) and the Ethics Committee in Osaka Metropolitan
38
39 727 University (approval number: 2024-068).
40

41 728 Written informed consents will be sought from study participants before the baseline survey, installation of
42
43 729 ceiling nets, each cross-sectional survey, and the start of prospective cohort surveys. In cross-sectional and
44
45 730 cohort surveys, informed assent will be obtained from children under the age of 15 who can understand the
46
47 731 study at a level appropriate for their development, in addition to the consent of a parent or legal guardian.
48
49 732 Participants have the right to withdraw from the study at any time, and the option to withhold previously
50
51 733 collected samples from any future analyses and studies.
52

53 734 The samples collected in this study may potentially be used for other research purposes. This is clearly stated
54
55
56 735 in the informed consent form. In such cases, we will obtain the necessary ethical approval and provide
57
58 736 participants with the chance to opt-out from this. All experiments will be carried out in adherence to WHO
59
60 737 requirements and the Declaration of Helsinki.

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Consent for publication {32}

We will not present identifying images or other personal or clinical details of participants. The participant information materials and informed consent form are available from the corresponding author on request.

Competing interests {28}

AK and JG were partially supported by a research grant from Sumitomo Chemical Corporation. Other authors had no competing interests.

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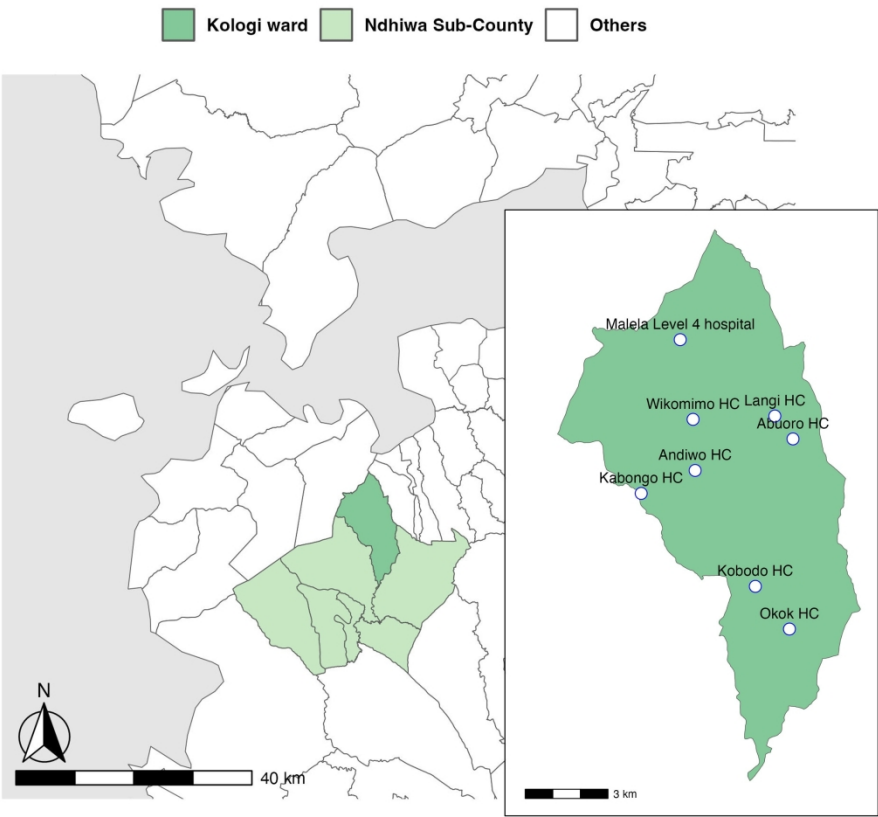
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Figure 1: Map of the study area. Inset shows the locations of the level four hospital and seven health centers (HC) in Kanyamwa Kologi Ward.

Figure 2: The schedule of trial activities.

Figure 3: CONSORT flow diagram and the detail of each survey



Map of the study area. Inset shows the locations of the level four hospital and seven health centers (HC) in Kanyamwa Kologi Ward.

216x179mm (330 x 330 DPI)

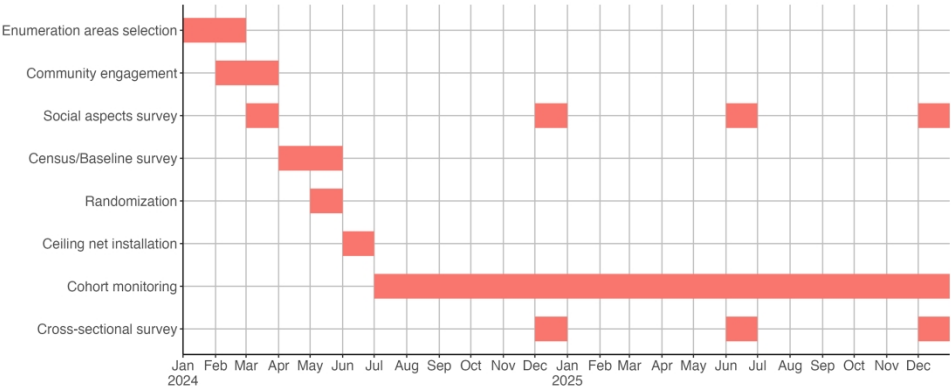
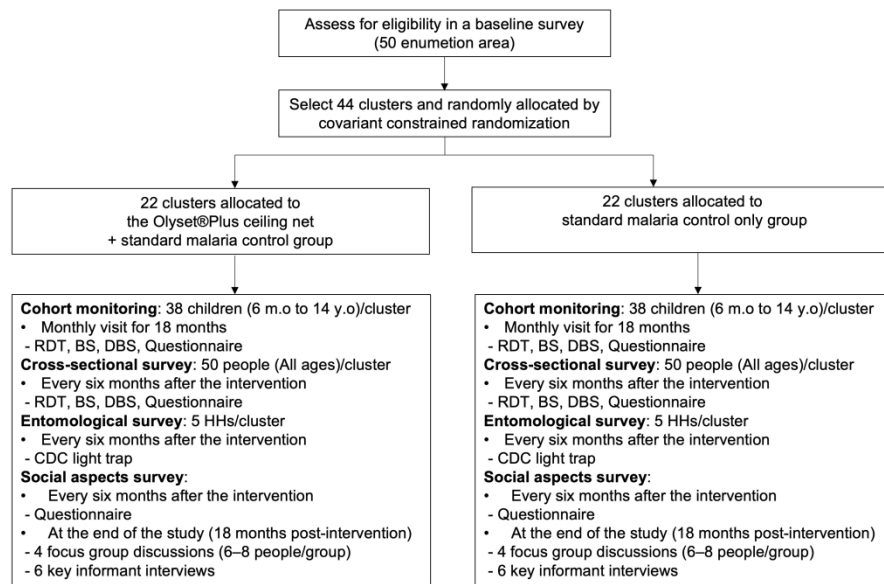


Figure 2: The schedule of trial activities.
304x127mm (310 x 310 DPI)



CONSORT flow diagram and the detail of each survey

288x186mm (330 x 330 DPI)

Evaluation of the protective efficacy of Olyset®Plus ceiling nets for reduction of malaria incidence children in Homa Bay County, Kenya: statistical analysis plan for clinical and epidemiological outcomes

Version 6.0

Nov 1, 2024 prepared by Yura K Ko (yongra.ko@ki.se)

SAP revisions

Version	Date	Summary of Changes
1.0	Jan 23, 2024	First draft
2.0	Feb 5, 2024	Added more details based on collaborators' feedback
3.0	Mar 4, 2024	Revised by the senior statistician (Dr. Daisuke Yoneoka)
4.0	April 9, 2024	Revised based on collaborators' feedback
5.0	Jun 4, 2024	Changed the cohort monitoring interval to one month due to feasibility after discussion with CHPs and local research staff.
6.0	Nov 1, 2024	1) Removed the secondary objective of time-to-first infection because it is impossible to ascertain the outcome without initial parasite clearance at enrollment. 2) Modified the definition of infection incidence based on the journal reviewer's comments.

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Introduction

Objectives

Primary objective:

- To determine the protective efficacy of **pyrethroid-PBO** (Olyset®Plus) ceiling nets in reducing malaria case incidence in children 6 months-14 years for 18 months post-intervention

Secondary objectives:

1. To determine the protective efficacy of **pyrethroid-PBO** ceiling nets in reducing malaria infection prevalence in all age groups at 6-, 12-, and 18-months post-intervention
2. To determine the spillover effects of **pyrethroid-PBO** ceiling nets in reducing malaria infection prevalence in all age groups at 6-, 12-, and 18-months post-intervention
3. To determine the protective efficacy of **pyrethroid-PBO** ceiling net in reducing malaria infection incidence in children 6 months to 14 years old over 18 months post-intervention.

Study Methods

Trial design

The study is a cluster-randomized controlled trial (CRCT) with 44 clusters evenly divided between the intervention and the control arms. Each cluster will be one or two villages consisting of at least 50 households. A baseline survey will be conducted to determine pre-intervention *Plasmodium* prevalence and to collect demographic and socioeconomic data for covariate-constrained randomization of clusters. The baseline survey will be conducted approximately one month before randomization. The post-intervention follow-up period will be 18 months. Thirty-eight children aged 6 months to 14 years from each cluster will be recruited and followed for 18 months as a cohort to determine the protective efficacy of the **pyrethroid-PBO** ceiling net on clinical malaria incidence (primary objective) and *Plasmodium* infection incidence (secondary objectives). Cross-sectional surveys will be conducted at 6, 12, and 18 months post-intervention targeting 50 individuals of all ages from each cluster to determine the overall *Plasmodium* prevalence and to estimate the spillover effect (secondary objectives).

Randomization

After the baseline survey, covariate-constrained randomization will be used to allocate the 44 clusters across the two study arms. Covariate-constrained allocation ensures that the arms are balanced overall by excluding allocations where predetermined factors are not balanced within set margins. The following factors will be constrained: baseline malaria infection prevalence by RDT in children aged 0.5–14 years, LLIN usage, malaria vaccine coverage, socioeconomic status (SES), population size, the proportion of eligible houses for the ceiling net installation, and vector densities. For the proportions of interest, we require the average difference between the arms of no more than 10% for the means of interest, and we require the difference in means to be no more than a quarter of the standard deviation of the variable among individuals in the population. After enumerating the allocations that fulfil the criteria, we may relax or tighten up the balance criteria when the allocated number is too small or very large. One allocation will be selected randomly among all possible allocations meeting the balancing constraints. Data on any additional potentially confounding ecological factors not included in the covariate-constrained randomization will be collected and adjusted for in the analysis. An independent statistician will perform the randomization.

Sample size

The sample size was calculated using the method of Hayes and Moulton¹. All sample sizes will be recalculated based on the baseline data, which will be collected before the ceiling net installation.

The following calculations were based on the historical data collected from the same Lake Victoria region in Kenya with a clinical malaria incidence rate of 0.5 per person-year for children under 14 years old by RDT (personal communication), 40% parasite prevalence for all age groups by PCR, and a between-cluster coefficient of variation (CV) of incidence rate = 0.24 in both arms. In the study site, RTS, S vaccination began in 2019, with an additional mass distribution of pyrethroid-PBO LLINs at the end of 2023. Therefore, the intervention effect is expected to be smaller than in previous studies and was conservatively assumed to be 25%. Assuming 38 individuals per cluster to be followed for up to 18 months with 20 % loss-to-follow up rate, we require 22 clusters per arm to achieve 80% power to detect a significant incidence rate ratio of 0.75 (25% protective efficacy) at a two-sided type 1 error of 5%. With 44 clusters and 50 individuals per cluster, for the outcome of *Plasmodium* prevalence by PCR, we would achieve 80% power to detect a 23.5 % relative reduction. We do not specify the sample size for identifying spillover effects because spillovers tend to have smaller effect sizes relative to total or overall effects, so typically larger sample sizes are required to detect them. Although our study may be underpowered to detect spillovers, we will report the results as an exploratory analysis.

Framework

Our null hypothesis for the primary outcome is that pyrethroid-PBO ceiling nets + standard malaria treatment and prevention measures do not reduce the clinical malaria incidence compared to standard malaria treatment and prevention measures in children 6 months to 14 years at 18 months post-intervention.

Statistical interim analyses and stopping guidance

Neither the ceiling nets nor synergist PBO are known to pose significant health and safety risks. This has also been demonstrated in our previous CRT on Mfangano Island². Therefore, no interim analysis is planned.

Timing of final analysis

We will conduct the final analysis after 18 months of follow-up. Results will immediately be submitted for publication in peer-reviewed journals.

Timing of outcome assessments

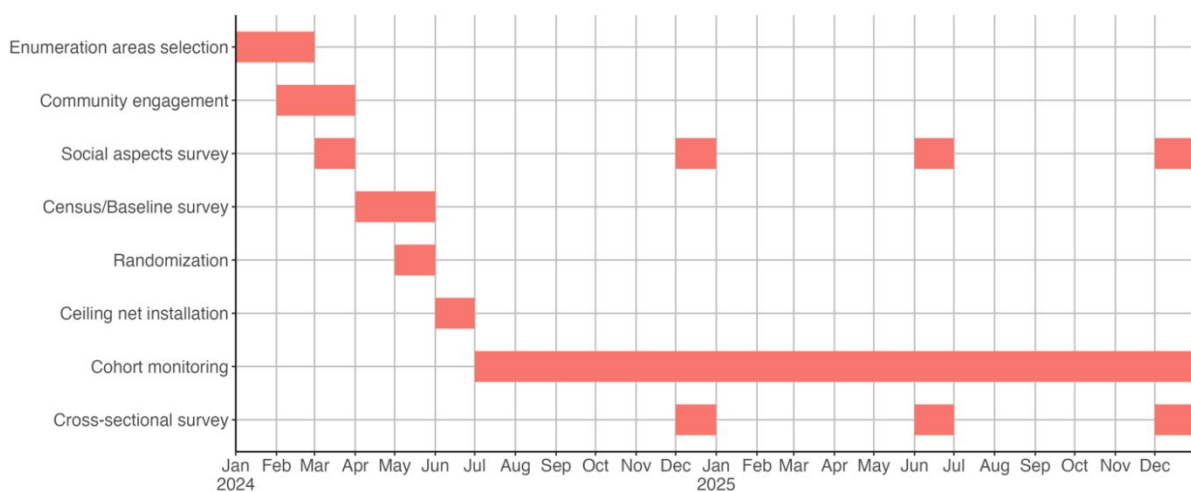


Figure1: Timetable of trial activities

Statistical Principles

Confidence intervals and P values

We will use a two-sided significance level of $\alpha = 0.05$ for hypothesis testing. All statistical tests will be conducted at this predetermined level of significance unless otherwise specified. For each estimated parameter, 95% confidence intervals will be calculated and reported.

Adherence and protocol deviations

Since the intervention (ceiling net) will be installed in trial participants' houses, participants not sleeping in their own houses will not benefit from the intervention. In the cohort, non-adherence to the intervention can be inferred from travel history during monthly interviews. Therefore, participants who regularly sleep outside their homes will be removed from the analyses. In addition, if a cohort participant is absent for three consecutive visits or for more than half of all visits, the child will be excluded from the analysis. Other protocol deviations will be carefully documented and categorized during the study.

Analysis populations

The intention to treat (ITT) analysis is the primary analysis approach for both the primary and secondary objectives. The per-protocol (PP) analysis is included as a supplementary analysis for the primary and secondary objectives.

Trial population

Screening data

Screening data will be collected during the cohort enrollment and each cross-sectional survey to assess the eligibility of potential participants. This information will include demographic characteristics such as age, sex, SES, and other relevant parameters outlined in the study protocol.

Eligibility

The inclusion criteria for the installation of the **pyrethroid-PBO** ceiling net are (1) residential structures housing at least one permanent resident aged 18 years or older in the household, (2) informed consent provided by at least one adult in the household and (3) applicable house structure for the ceiling net in terms of size of the structure, presence of eave, ceiling board, and vertical beams, and material of the top part of the wall. The applicability of the ceiling net installation will be assessed by experienced field staff. The exclusion criteria are (1) vacant dwelling structure (confirmed by at least two visits by CHPs), (2) dwelling structure to be vacated or destroyed within the study period and (3) **non-eligible** house structure for the ceiling net installation.

The inclusion criteria for prospective cohorts of children aged 6 months to 14 years old are (1) living in the study area at the time of **pyrethroid-PBO** ceiling net installation, (2) having no plan to leave or stay outside the study area for an extended period (longer than 1 month) over the 18-month follow-up period, and (3) informed consent provided by the participant's parent or guardian. The exclusion criterion is having severe chronic illnesses.

The inclusion criteria for cross-sectional malaria surveys for all age groups are (1) living in the study area during the study period, and (2) informed consent being provided by the parent or legal guardian before each survey. The exclusion criterion is having severe chronic illnesses.

Recruitment

For the baseline survey, we will randomly choose 50 enumeration areas (comprising one or two villages) in Kanyamwa Kologi Ward, Ndhiwa Sub-County. The survey includes a questionnaire for all households, mRDT testing of all children aged 6 months to 14 years. We will not create buffer zones to minimize contamination since a buffer zone of 400–600 m from the boundary will greatly reduce the number of houses in the core area available for analysis in many clusters. Thirty-eight eligible children will be randomly recruited into our cohort in each cluster. Recruitment will be limited to children aged 12 or younger, to prevent children from aging out during the 18 months monitoring period. For the cross-sectional survey at each time point, we will randomly select 50 individuals of all age groups from each

cluster. To reflect the age structure of the populations, the selection will be done with age category stratifications.

Withdrawal/follow-up

Those who migrate between the arms or emigrate from the study areas, or those who dismount the ceiling net from their house structure will be dropped from the intervention. For the cohort, those who are absent for three consecutive visits or for more than half of all visits will be excluded from the analysis as lost to follow-up. A summary of study participant selection is shown in Figure 2.

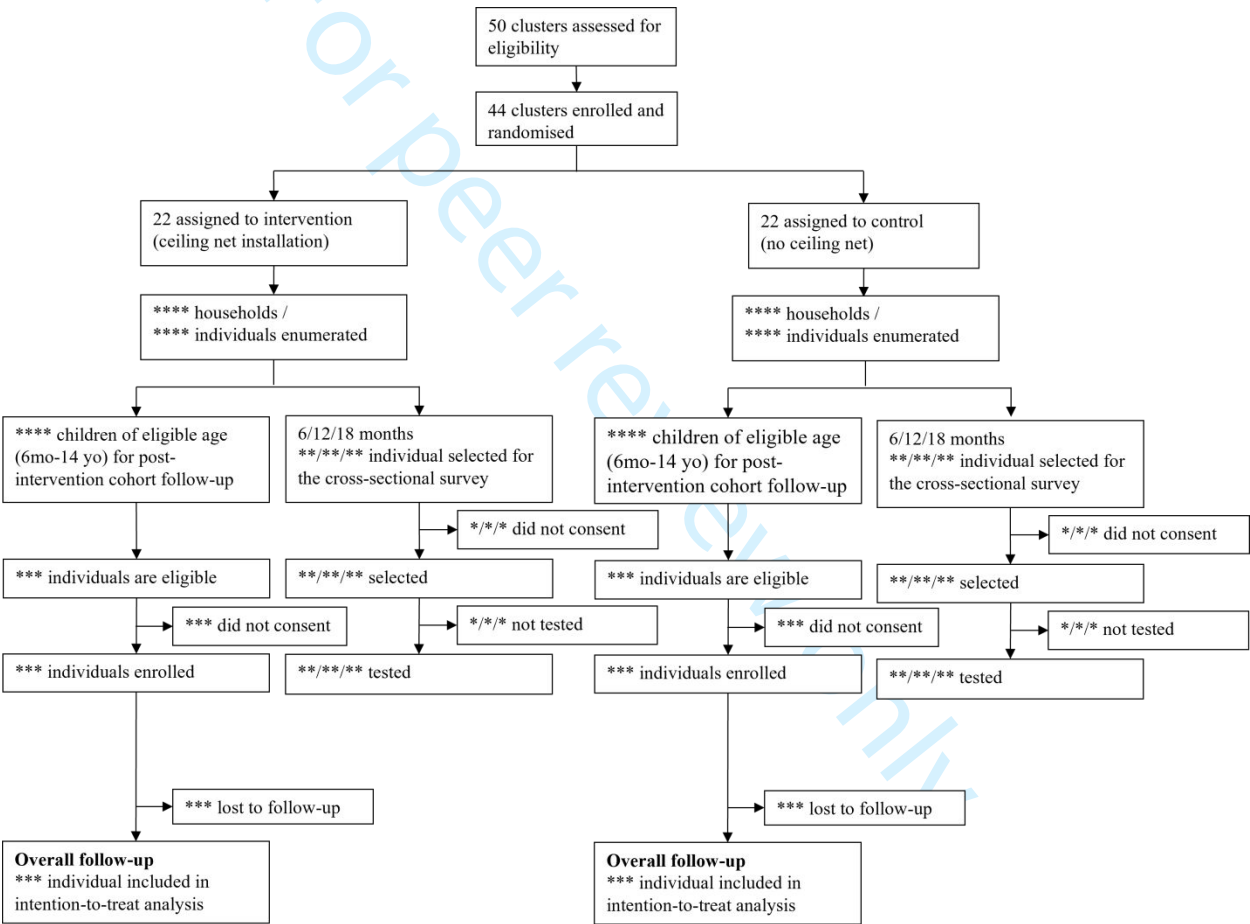


Figure 2: A schematic flow diagram of cluster allocation and study participant selection.

Baseline characteristics

We will report a list of baseline characteristics of the intervention and control arms. The list will include population, mean number of people per household, median age of population, number of selected children

for the cohort monitoring, number of selected individuals for each cross-sectional survey, malaria infection prevalence by RDT in children aged 0.5–14 years, LLIN usage, malaria vaccine coverage among children, SES, the proportion of suitable houses for the ceiling net installation, the mean indoor vectors per household per night.

Analysis

Endpoints

Primary endpoint:

- Overall malaria case incidence in children 6 months-14 years among intervention and control clusters during the 18-month follow-up period.

Secondary endpoints:

1. Malaria infection prevalence by PCR at 6, 12, and 18 months post-intervention in all age groups among intervention and control clusters.
2. Malaria infection incidence by PCR in children 6 months-14 years among intervention and control clusters during the 18-month follow-up period.

Definition of malaria case incidence

Incidence of clinical malaria in the prospective cohort will be estimated by both active and passive case detections. For active case detection, we will visit the home of cohort participants every month. At each monthly visit, axillary temperature will be taken from each cohort participant. A clinical case is defined as positive mRDT accompanied by fever ($>37.5^{\circ}\text{C}$) or any malaria-related symptoms during or within 48 hours of the home visit. All participants with positive mRDT will be treated with artemether-lumefantrine (artemisinin-based combination therapy [ACT]). For passive case detection, we ask all cohort participants to visit designated health facilities in case they suspect malaria between home visits.

If two consecutive RDTs are positive, there are two patterns: active case detection or passive case detection for the detection of the second positive. If the second positive RDT is detected by active case detection, we will refer the child to a health facility and regard it as a new malaria infection if subsequent microscopy or PCR confirms parasites after 15 days or more passed from the first RDT test. If not, it is considered a carryover from the previous infection. For the passive case detection of a second RDT positive, we will regard it as a new malaria infection if more than 14 days have passed since the first RDT test.

For the overall incidence rate calculation, the time at the risk will be adjusted by subtracting the 14 days

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of “protection period” of ACT. If a participant misses a particular visit or a second positive is considered a carryover from the previous infection, the period is not included in the at-risk period.

If the cohort children visit health care facility and get tested for malaria between each visit, both positive and negative results will be utilized for our analysis. Specifically, the 14 days prior to the test result will be incorporated into the denominator of the incidence calculation as the at-risk period. Specific patterns for incidence rate calculation are shown in Figure 3.

If a participant is absent for three consecutive visits or for more than half of all visits, the child will be excluded from the analysis.

Definition of malaria infection incidence

In addition, we will test all cohort children by PCR every month. For the secondary outcome, the infection incidence is defined as the total number of monthly PCR-positive tests per individual divided by the total number of tests conducted per individual per time period, as described in Bennett et al³. If two consecutive PCR results are positive, the second positive result will be removed only if no treatment was provided in the previous month. Furthermore, as a supplementary analysis, we will include passively detected cases in the infection incidence counts to capture any new infections after the passive case treatment by each health center. Passively detected positives will be assigned to the closest active visit—either the one immediately before or after the passive case detection—depending on which is closer in time.

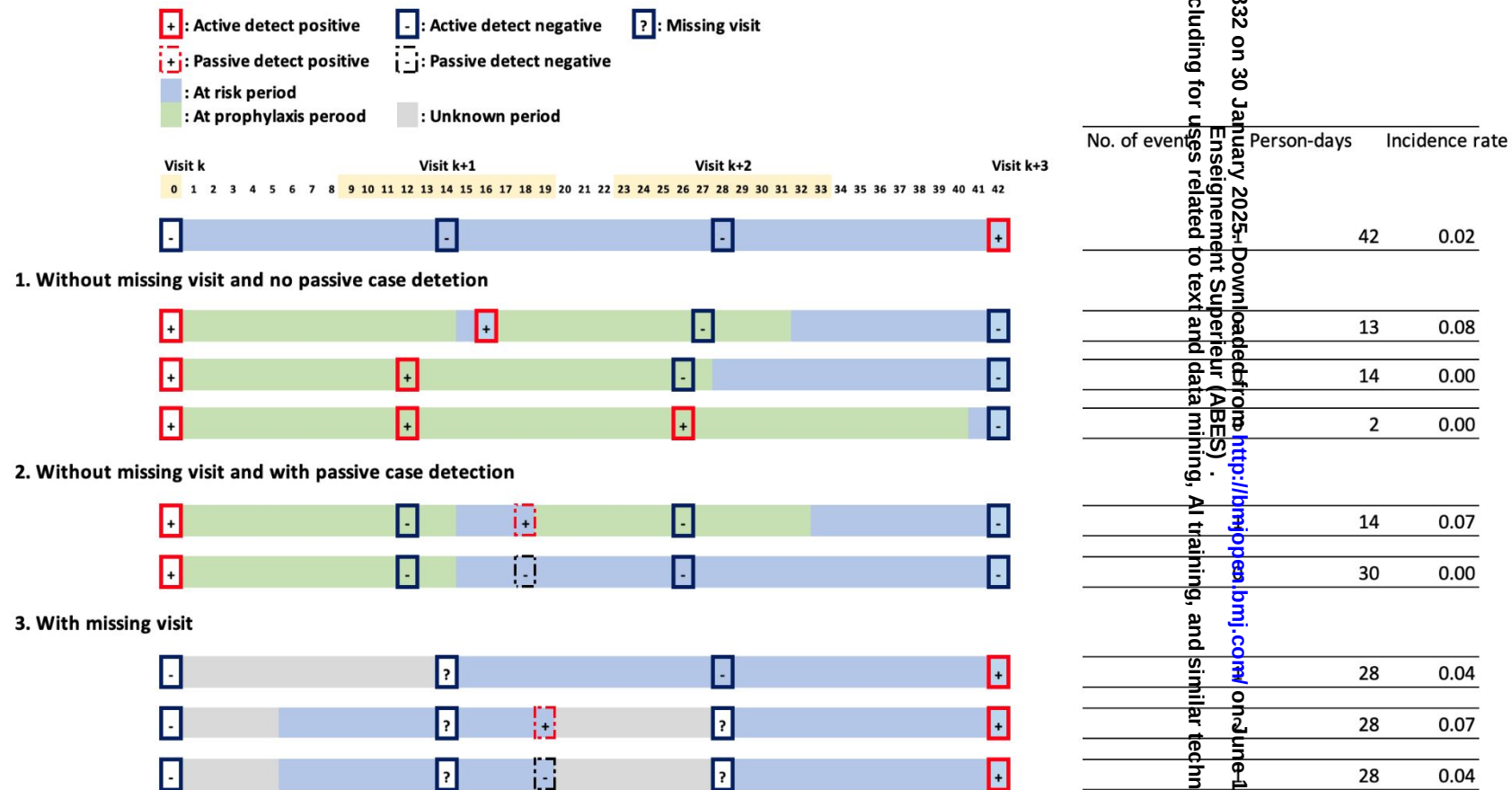


Figure 3: Specific patterns for case incidence rate calculation.

Analysis methods

We will follow the CONSORT guidelines extended for CRT⁴ for the statistical analysis and results reporting.

Clinical malaria incidence

We will determine the protective efficacy of pyrethroid-PBO ceiling nets against malaria case incidence by comparing clinical malaria incidence rates between arms. We will use mixed effects negative binomial regression accounting for within-cluster correlation of responses by following equations:

$$\begin{aligned}\mu_{k,i} &= \exp(\beta_0 + \mathbf{x}_{k,i}^T \boldsymbol{\beta} + z_k), \\ z_k &\sim N(0, \sigma^2),\end{aligned}$$

where $\mu_{k,i}$ is the mean incidence rate of individual i in cluster k , $\mathbf{x}_{k,i}$ is the covariate vector including individual and cluster level data, z_k is the Gaussian-type random effect at the cluster level. The protective efficacy will be estimated by $(1 - \exp(\hat{\beta})) \times 100\%$, where $\hat{\beta}$ is the estimated regression coefficient of the treatment. Possible confounding factors such as age, sex, bed net usage, house structure, and SES will be adjusted as well as the covariates used in the covariate-constrained randomization. In addition, because we will not set a buffer zone, the distance to the nearest household in the other arm will be adjusted as a covariate to reduce the contamination between two arms. The variable was selected from the previous study⁵.

Prevalence of malaria infection

The secondary outcome, prevalence of malaria infection by PCR and microscopy measured at 6-, 12-, and 18-months after the ceiling net installation will be analyzed using mixed effects logistic regression adjusting for the above-mentioned confounding factors.

Exploratory analysis for spillover effects

Evidence for positive spillover effects of the ceiling net on malaria infection prevalence of all age group will be assessed by comparing individuals with no intervention conditioning 1) the distance to ceiling net installed household, and 2) the coverage of surrounding households with ceiling net within 400 m (Figure 4). The distance of 400 m was chosen as the spillover effect appears to attenuate at this distance based on previous reports⁶. As there may be a bias that households without a ceiling net in the intervention cluster have different characteristics (e.g. preventive behaviour against malaria), we will include only control clusters for the spillover analysis to ensure comparability.

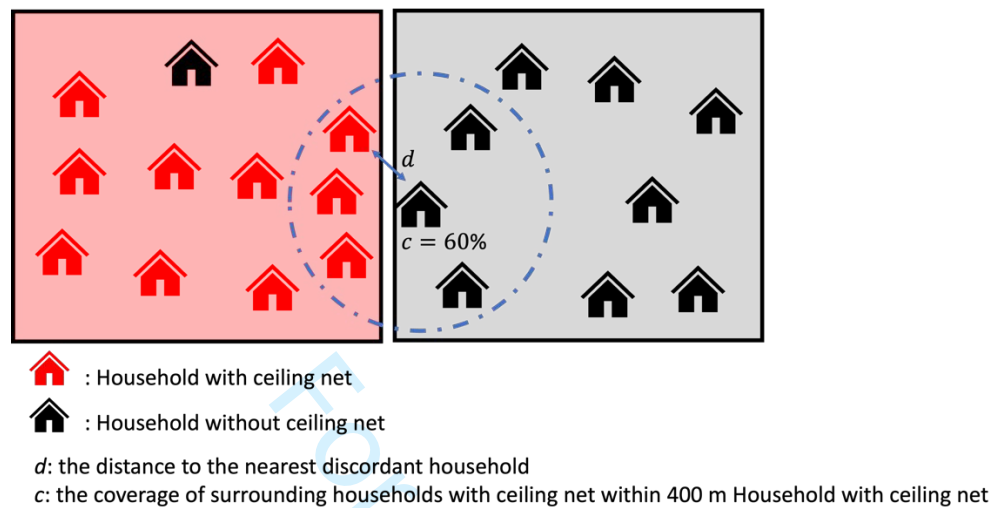


Figure 4: The distance to the nearest discordant household and the coverage of treatment.

Missing data

We will make substantial effort to avoid having missing values on outcome (malaria infection status and visit dates) by encouraging individual participants and CHPs repeatedly. When missing values occur for an outcome for reasons not related to the outcome, reasons for missingness and the missing fraction by treatment arm and cluster will be reported. Per protocol, the subjects are screened actively on their malaria status (the outcome) every four weeks.

In both cases, all the available data from the subject will be included in the primary and secondary analysis, without employing any specific missing data analysis techniques, due to the ignorability of the missing mechanisms. Missing baseline covariates (individual-level, household-level, and cluster-level) that are a part of the regression models for the outcome of interest will be imputed using simple hot-deck imputation methods if the missing fraction for the covariate is $<5\%$. If the missing fraction for a covariable is $\geq 5\%$, appropriate multiple imputation approaches will be applied. If a non-ignorable portion of the subjects have missing values on a covariate (due to missing at random or missing completely at random), that covariate may be excluded in the model.

Additional analysis

We will perform the same analysis for three age subgroups (≤ 59 months old; 5 years old to 14 years old; 15 years old or older) to examine if the effects of **pyrethroid-PBO** ceiling net differ by age groups. In addition, we will perform other machine learning based approach such as causal forest and super learner to estimate the conditional average treatment effect.

Harms

All unanticipated problems will be reported to the research team and Homa Bay County Ministry of Health (MOH) through CHPs. Medical officers from Homa Bay County will assess the relatedness of the reported events to the study and report to the research team, including the PI. In the event of a study-related serious adverse event, the study team will convene a meeting immediately with the MOH and Homa Bay County Teaching and Referral Hospital representatives to review the case and take necessary action. Also, the ceiling net is made of the same materials and chemicals as LLIN already on the market, and is therefore not expected to have significant environmental impact.

Statistical software

For all data handling and analysis, we will use R software version 4.3.2 (R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.)

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3 6. Hawley, W. A. *et al.* Community-wide effects of permethrin-treated bed nets on child mortality and
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0. Consent form

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2Please complete the survey below.

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4Thank you!

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8Please make sure to show the consent form on the tablet.

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10I have read the information about the study and have

11received answers to any questions I asked.

12I consent to take part in all the activities mentioned

13above.

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16Name of participant

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19Signature of participant

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24Name of witness

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27Signature of witness

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32Do you have a child to participate in the study?

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36Check the following box.

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41Parent/Guardian's name

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44Parent/Guardian's signature

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49Witness: I hereby confirm that the study has been

50explained to the parent/ guardian. All questions (if

51any) have also been answered to his/ her satisfaction,

52and he/ she, of his/ her own free will, has consented

53for his/ her child to take part in the study.

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55Name of witness

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57Signature of witness

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Enseignement Supérieur (ABES).

1. Structure

Please complete the survey below.

Thank you!

Longitude

Latitude

Is this structure the first registration in the household?

☐ Yes

☐ No

Record the structure ID of the first structure in this household

(i.g. 12-1-7)

Name of the village

What is the main source of drinking water for members of your household?

☐ PIPED INTO DWELLING

☐ PIPED TO YARD/PLOT

☐ PIPED TO NEIGHBOR

☐ PUBLIC TAP/STANDPIPE

☐ DUG PROTECTED WELL

☐ DUG UNPROTECTED WELL

☐ WATER FROM PROTECTED SPRING

☐ WATER FROM UNPROTECTED SPRING

☐ RAINWATER

☐ TANKER TRUCK

☐ CART WITH SMALL TANK

☐ SURFACE WATER (RIVER/DAM/LAKE/POND/STREAM/CANAL/IRRIGATION CHANNEL)

☐ BOTTLED WATER

☐ OTHER

Specify it.

What is the main source of water used by your household for other purposes such as cooking and handwashing?

☐ PIPED INTO DWELLING

☐ PIPED TO YARD/PLOT

☐ PIPED TO NEIGHBOR

☐ PUBLIC TAP/STANDPIPE

☐ DUG PROTECTED WELL

☐ DUG UNPROTECTED WELL

☐ WATER FROM PROTECTED SPRING

☐ WATER FROM UNPROTECTED SPRING

☐ RAINWATER

☐ TANKER TRUCK

☐ CART WITH SMALL TANK

☐ SURFACE WATER (RIVER/DAM/LAKE/POND/STREAM/CANAL/IRRIGATION CHANNEL)

☐ OTHER

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Specify it.

Where is that water source located?

- ☐ IN OWN DWELLING
☐ IN OWN YARD/PLOT
☐ ELSEWHERE

How long does it take to go there, get water, and come back? (MINUTES)

What kind of toilet facility do members of your household usually use?

IF NOT POSSIBLE TO DETERMINE, ASK PERMISSION TO OBSERVE THE FACILITY.

- ☐ FLUSH TO PIPED SEWER SYSTEM
☐ FLUSH TO SEPTIC TANK
☐ FLUSH TO PIT LATRINE
☐ FLUSH TO SOMEWHERE ELSE
☐ FLUSH, DON'T KNOW WHERE
☐ VENTILATED IMPROVED PIT LATRINE
☐ PIT LATRINE WITH SLAB
☐ PIT LATRINE WITHOUT SLAB/OPEN PIT
☐ COMPOSTING TOILET
☐ BUCKET TOILET
☐ HANGING TOILET/HANGING LATRINE
☐ NO FACILITY/BUSH/FIELD
☐ OTHER

Specify it.

Do you share this toilet facility with other households?

- ☐ Yes
☐ No

Including your own compound, how many households use this toilet facility?

- ☐ LESS THAN 10 HOUSEHOLDS
☐ 10 OR MORE HOUSEHOLDS
☐ DON'T KNOW

Including your own household, how many households use this toilet facility (if less than 10)?

Where is this toilet facility located?

- ☐ IN OWN DWELLING
☐ IN OWN YARD/PLOT
☐ ELSEWHERE

In your household, what type of cooking device (cookstove) is mainly used for cooking?

- ☐ ELECTRIC STOVE
☐ SOLAR COOKER
☐ LIQUEFIED PETROLEUM GAS (LPG)/COOKING GAS STOVE
☐ PIPED NATURAL GAS STOVE
☐ BIOGAS STOVE
☐ LIQUID FUEL STOVE
☐ MANUFACTURED SOLID FUEL STOVE (i.g. Jiko)
☐ THREE STONE STOVE/OPENFIRE
☐ NO FOOD COOKED IN THE HOUSEHOLD
☐ OTHER

Specify it.

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What type of fuel or energy source is mainly used in this cookstove?

☐ ALCOHOL/ETHANOL

☐ GASOLINE/DIESEL

☐ KEROSENE/PARAFFIN

☐ COAL/LIGNITE

☐ CHARCOAL

☐ WOOD

☐ STRAW/SHRUBS/GRASS

☐ AGRICULTURAL CROP

☐ ANIMAL DUNG/WASTE

☐ PROCESSED BIOMASS (PELLETS) OR WOODCHIPS

☐ GARBAGE/PLASTIC

☐ SAWDUST

☐ OTHER

Specify it.

How many rooms in this household are used for sleeping?

Does this household own any livestock, herds, other farm animals, or poultry?

☐ Yes

☐ No

How many of the following (animals) livestock does this household own?

- Local cattle (indigenous)

How many of the following (animals) livestock does this household own?

- Exotic/grade cattle

How many of the following (animals) livestock does this household own?

- Horses

How many of the following (animals) livestock does this household own?

- Donkeys

How many of the following (animals) livestock does this household own?

- Mules

How many of the following (animals) livestock does this household own?

- Goats

How many of the following (animals) livestock does this household own?

- Sheep

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How many of the following (animals) livestock does this household own? _____

- Chickens or other poultry

How many of the following (animals) livestock does this household own? _____

- Pigs

Does any member of this household own any agricultural land?

☐ Yes
☐ No

Do you know how many acres of agricultural land do members of this household own?

☐ Yes
☐ No

How many acres of agricultural land do members of this household own? _____

ACRES

Does your household have:

- ☐ Electricity?
- ☐ A radio?
- ☐ A television?
- ☐ A fixedline telephone?
- ☐ A computer?
- ☐ A refrigerator?
- ☐ A solar panel?
- ☐ A table?
- ☐ A chair?
- ☐ A sofa?
- ☐ A bed?
- ☐ A cupboard?
- ☐ A clock?
- ☐ A microwave oven?
- ☐ A DVD player?
- ☐ A CD player?

Does any member of this compound own:

- ☐ A wrist watch?
- ☐ A mobile phone?
- ☐ A bicycle?
- ☐ A motorcycle or motor scooter?
- ☐ An animal-drawn cart?
- ☐ A car or truck?
- ☐ A boat with a motor?

Does any member of this household have an account in a bank or other financial institution?

☐ Yes
☐ No

Does any member of this household use a mobile phone to make financial transactions such as sending or receiving money, paying bills, purchasing goods or services, or receiving wages?

☐ Yes
☐ No

In the past year, has this household ever used mosquito repellent spray (e.g. Doom), ointments, vaporizers coils, herbs, or plants to protect against mosquitoes/malaria?

☐ Yes
☐ No

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Does your household have any bed nets?

☐ Yes

☐ No

How many mosquito nets does your household have?

Will you accept to install the ceiling net if you are offered?

☐ Yes

☐ No

What is the reason for not installing the ceiling net?
Select all that apply.

☐ Air flow disturbance

☐ Heat

☐ Appearance

☐ Pets

☐ Fire

☐ Social culture and religious factor

☐ Others

Specify it

Do you have any concerns about the ceiling net?
Select all that apply.

☐ Air flow disturbance

☐ Heat

☐ Appearance

☐ Pets

☐ Fire

☐ Social culture and religious factor

☐ No concern

☐ Others

Specify it

OBSERVE MAIN MATERIAL OF THE FLOOR OF THE DWELLING/SLEEPING ROOM.

☐ EARTH/SAND

☐ DUNG

☐ WOOD PLANKS

☐ PALM/BAMBOO

☐ PARQUET OR POLISHED WOOD

☐ VINYL OR ASPHALT STRIPS

☐ CERAMIC TILES

☐ CEMENT

☐ CARPET

☐ OTHER

RECORD OBSERVATION.

Specify it.

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OBSERVE MAIN MATERIAL OF THE ROOF OF THE DWELLING.

RECORD OBSERVATION.

- ☐ NO ROOF
☐ THATCH/PALM LEAF
☐ RUSTIC MAT
☐ PALM/BAMBOO
☐ WOOD PLANKS
☐ CARDBOARD
☐ IRON SHEETS
☐ WOOD
☐ CALAMINE/CEMENT FIBER
☐ BRICK/CLAY TILES
☐ CEMENT
☐ ROOFING SHINGLES
☐ OTHER

Specify it.

OBSERVE MAIN MATERIAL OF THE EXTERIOR WALLS OF THE DWELLING.

RECORD OBSERVATION.

- ☐ NO WALLS
☐ WOOD WITH MUD
☐ IRON SHEET
☐ BRICKS
☐ CANE/PALM/TRUNKS
☐ BAMBOO WITH MUD
☐ STONE WITH MUD
☐ UNCOVERED ADOBE
☐ PLYWOOD
☐ CARDBOARD
☐ REUSED WOOD
☐ CEMENT
☐ STONE WITH LIME/CEMENT
☐ CEMENT BLOCKS
☐ COVERED ADOBE
☐ WOOD PLANKS/SHINGLES
☐ OTHER

Specify it.

OBSERVE EAVES OF THE DWELLING.

RECORD OBSERVATION.

- ☐ Open
☐ Partly open
☐ Close

OBSERVE BEAMS OF THE DWELLING.

RECORD OBSERVATION.

- ☐ No vertical beam
☐ One vertical beam
☐ More than one vertical beams

Tick all that apply

- ☐ 2 or more vertical beams in the same room
☐ Ceiling board/ Flat roof
☐ The roof is very low
☐ The room is used for kitchen
☐ None

Has this structure been done with IRS (Indoor Residual Spraying) within three years?

- ☐ Yes
☐ No

When did you have IRS?

- ☐ 2021
☐ 2022
☐ 2023
☐ Don't know

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Is there a child living in this structure?

☐ Yes

☐ No

"Living" means that the child usually stay in the household. If the child is usually staying at a boarding school, but now he/she is staying in this house because of a school closure, that is not regarded as "living".

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Once you complete, "Show More Save Options">"Save & Go to Next Form"

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2. Children

Please complete the survey below.

Thank you!

Skip this page because there is no children and "Show More Save Options">"Save & Go to Next Form".

Now we would like to record the names of all children aged under 18.

But RDT tests are for children from 6 month to 14 years old.

RECORD TWINS AND TRIPLETS SEPARATELY.

What name was given to the child?

First name

What name was given to the child?

Middle name

What name was given to the child?

Last name

Is the child a boy or a girl?

- ☐ BOY
☐ GIRL

Was that a single or multiple pregnancy?

- ☐ SING
☐ MULT

Do you know the birthday of the child?

- ☐ Yes
☐ No

On what day, month, and year was the child born?

How old was the child at the last birthday?

The birthday and your age are contradicting. Please check the true age again.

Is the child living with you?

- ☐ Yes
☐ No

"Living with" means that you and the child usually stay in the same household. If the child is usually staying at a boarding school, but now he/she is being with you because of a school closure, that is not regarded as "living with you".

Has the child been ill with a fever at any time in the last 2 weeks?

- ☐ YES
☐ NO
☐ DON'T KNOW

1

At any time during the illness, did the child have

2

blood taken from a finger or heel for testing?

3

☐ YES

☐ NO

☐ DON'T KNOW

4

5

Were you told by a healthcare provider that the child

6

had malaria?

7

☐ YES

☐ NO

☐ DON'T KNOW

8

9

Did you seek advice or treatment for the illness from

10

any source?

11

☐ Yes

☐ No

12

13

How many times did you seek advice or treatment for

14

the illness from any source?

15

16

Where did you first seek advice or treatment? Anywhere

17

else?

18

☐ GOVERNMENT HOSPITAL

☐ GOVERNMENT HEALTH CENTER

☐ GOVERNMENT DISPENSARY

☐ GOVERNMENT MOBILE CLINIC

☐ COMMUNITY HEALTH WORKER/FIELD WORKER

☐ PRIVATE HOSPITAL

☐ PRIVATE CLINIC

☐ PHARMACY

☐ PRIVATE DOCTOR

☐ PRIVATE MOBILE CLINIC

☐ COMMUNITY HEALTH WORKER

☐ SHOP

☐ TRADITIONAL PRACTITIONER

☐ MARKET

☐ ITINERANT DRUG SELLER

☐ OTHER

19

PROBE TO IDENTIFY THE TYPE OF SOURCE.

20

IF UNABLE TO DETERMINE IF PUBLIC, PRIVATE, OR NGO

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SECTOR, RECORD 'OTHER'

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Specify it.

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Where did you second seek advice or treatment?

37

Anywhere else?

38

☐ GOVERNMENT HOSPITAL

☐ GOVERNMENT HEALTH CENTER

☐ GOVERNMENT DISPENSARY

☐ GOVERNMENT MOBILE CLINIC

☐ COMMUNITY HEALTH WORKER/FIELD WORKER

☐ PRIVATE HOSPITAL

☐ PRIVATE CLINIC

☐ PHARMACY

☐ PRIVATE DOCTOR

☐ PRIVATE MOBILE CLINIC

☐ COMMUNITY HEALTH WORKER

☐ SHOP

☐ TRADITIONAL PRACTITIONER

☐ MARKET

☐ ITINERANT DRUG SELLER

☐ OTHER

39

PROBE TO IDENTIFY THE TYPE OF SOURCE.

40

IF UNABLE TO DETERMINE IF PUBLIC, PRIVATE, OR NGO

41

SECTOR, RECORD 'OTHER'

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Specify it.

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Where did you third seek advice or treatment? Anywhere else?

PROBE TO IDENTIFY THE TYPE OF SOURCE.

IF UNABLE TO DETERMINE IF PUBLIC, PRIVATE, OR NGO SECTOR, RECORD 'OTHER'

- ☐ GOVERNMENT HOSPITAL
- ☐ GOVERNMENT HEALTH CENTER
- ☐ GOVERNMENT DISPENSARY
- ☐ GOVERNMENT MOBILE CLINIC
- ☐ COMMUNITY HEALTH WORKER/FIELD WORKER
- ☐ PRIVATE HOSPITAL
- ☐ PRIVATE CLINIC
- ☐ PHARMACY
- ☐ PRIVATE DOCTOR
- ☐ PRIVATE MOBILE CLINIC
- ☐ COMMUNITY HEALTH WORKER
- ☐ SHOP
- ☐ TRADITIONAL PRACTITIONER
- ☐ MARKET
- ☐ ITINERANT DRUG SELLER
- ☐ OTHER

Specify it.

How many days after the illness began did you first seek advice or treatment for the child?

IF THE SAME DAY RECORD '0'.

At any time during the illness, did the child take any medicine for the illness?

- ☐ Yes
- ☐ No

What medicine did the child take? Any other medicine?

RECORD ALL MENTIONED.
IF MEDICINE NOT KNOWN, ASK TO SEE THE PACKAGE OR PRESCRIPTION.

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOTALORDHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER
- ☐ DON'TKNOW

Specify it.

How long after the fever started did the child first take an artemisinin-based combination therapy?

- ☐ SAME DAY
- ☐ NEXT DAY
- ☐ TWO DAYS AFTER FEVER
- ☐ THREE OR MORE DAYS AFTER FEVER
- ☐ DON'TKNOW

Has [mis_wo213_1] received a malaria vaccine?

- ☐ Yes
- ☐ No

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How many times has [mis_wo213_1] received malaria vaccine?

☐ 1 dose

☐ 2 doses

☐ 3 doses

☐ 4 doses

☐ Don't know

Where does [mis_wo213_1] usually sleep?

☐ Bed room

☐ Kitchen room

☐ Others

Specify it.

Where Is [mis_wo213_1] usually living?

☐ This household

☐ Boarding school

☐ Relative's house outside the village

☐ Others

Specify it.

Did [mis_wo213_1] spend any nights outside your house in the last 30 days?

☐ Yes

☐ No

Where did [mis_wo213_1] spend those nights?

☐ Another house in Ndhiwa Sub-county

☐ Homa Bay county other than Ndhiwa

☐ Another county in Kenya

☐ Another country

How many nights did [mis_wo213_1] spend in another house in Ndhiwa?

How many nights did [mis_wo213_1] spend in another house in Homa Bay County other than Ndhiwa?

Specify the Sub-county name.

How many nights did [mis_wo213_1] spend in another house in another county in Kenya?

Specify the county name.

How many nights did [mis_wo213_1] spend in another house in another country?

Specify the country name.

Did the child sleep under a bed net last night?

☐ Yes

☐ No

RDT result for P.f

☐ Negative

☐ Positive

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RDT result for Pan

Negative

Positive

If there is another child, press "Show More Save Options">"Save & Add New Instance
otherwise, press "Show More Save Options">"Go to Next Form".

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3. Adults

Please complete the survey below.

Thank you!

Now, we would like to record the names of all adults who live in this household on a permanent or weekly basis. Do not include a person who stays only a few days in a month.

First name	
Middle name	
Last name	
Choose from the below.	☐ Permanent Resident ☐ Weekly Resident ☐ Monthly Resident ☐ Others
Sleep in this structure...	
More than half of the week = Permanent	
Few days in a week regularly = Weekly	
Few days in a month regularly = Monthly	
Other type of resident	
Answer his/her age with...	☐ birthday ☐ age ☐ age group
Birthday	
Age	
	(years old)
Age group	☐ High school ☐ After high school ☐ Was born before the independence of Kenya
Sex	☐ Male ☐ Female ☐ Other ☐ Prefer not to say

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1 Relation to the structure head

- ☐ Head
- ☐ Spouse (Husband or wife 1)
- ☐ Wife 2 or 3
- ☐ Parent
- ☐ Parent in law
- ☐ Child
- ☐ Child in law
- ☐ Brother/Sister
- ☐ Brother/Sister in law
- ☐ Grand Child
- ☐ Nephew/Niece
- ☐ Uncle/Aunt
- ☐ Worker
- ☐ Other relative
- ☐ Other non-relative

17 Relation to the compound head

- ☐ Head
- ☐ Spouse (Husband or wife 1)
- ☐ Wife 2 or 3
- ☐ Parent
- ☐ Parent in law
- ☐ Child
- ☐ Child in law
- ☐ Brother/Sister
- ☐ Brother/Sister in law
- ☐ Grand Child
- ☐ Nephew/Niece
- ☐ Uncle/Aunt
- ☐ Worker
- ☐ Other relative
- ☐ Other non-relative

32 Please repeat until you record all the members.
33 ("Show More Save Options">"Save & Add New Instance").
34

37 Once you complete all the member,
38 "Show More Save Options">"Save & Go to Next Form".
39

40 Note

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4. NET

Please complete the survey below.

Thank you!

ASK THE RESPONDENT TO SHOW YOU ALL THE NETS IN THE HOUSEHOLD. OBSERVE AND ANSWER THE QUESTIONS FOR EACH NET, ONE BY ONE.

Please name this net for the sake of identification.
i.e. boy's net, parent's net, net in the living room....

WAS THIS NET OBSERVED?

☐ Yes

☐ No

How many months ago did your household get the mosquito net?
IF LESS THAN ONE MONTH AGO, RECORD '00'.

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ 7

☐ 8

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☐ 32

☐ 33

☐ 34

☐ 35

☐ 36

☐ MORE THAN 36 MONTHS AGO

☐ NOT SURE

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OBSERVE OR ASK BRAND/TYPE OF MOSQUITO NET.

- ☐ OLYSET (SUPANET EXTRA)
☐ PERMANET (SUPANET EXTRA)
☐ VEERALIN
☐ NETPROTECT
☐ YORKKOL
☐ DAWAPLUS
☐ OTHER/DON'T KNOW BRAND (LLIN)
☐ OTHER TYPE (NOT LLIN)
☐ DON'T KNOW TYPE

Did you get the net through a distribution campaign, during an antenatal care visit, or during a child welfare visit?

- ☐ YES, MASS DISTRIBUTION CAMPAIGN
☐ YES, ANTENATAL CARE VISIT
☐ YES, CHILD WELFARE VISIT
☐ NO

Where did you get the net?

- ☐ GOVERNMENT HEALTH FACILITY
☐ PRIVATE HEALTH FACILITY
☐ PHARMACY
☐ SHOP/MARKET
☐ CHP
☐ RELIGIOUS INSTITUTION
☐ SCHOOL
☐ OTHER
☐ DON'T KNOW

Did anyone sleep under this mosquito net last night?

- ☐ YES
☐ NO
☐ NOT SURE

Who slept under this mosquito net last night?

RECORD THE PERSON'S NAME. IF THERE ARE MORE THAN ONE, RECORD ALL THE NAME CONNECTING BY ",".

What was the main reason this net was not used last night?

- ☐ TOO HOT
☐ DON'T LIKE NET SHAPE/COLOR/SIZE
☐ DON'T LIKE SMELL
☐ UNABLE TO HANG NET
☐ SLEPT OUTDOORS
☐ USUAL USER DIDN'T SLEEP HERE LAST NIGHT
☐ NO MOSQUITOES/NO MALARIA
☐ EXTRA NET/SAVING FOR LATER
☐ NET TOO SMALL/SHORT
☐ NET BROUGHT BED BUGS
☐ OTHER

Specify it

Note

If there is another net, press "Show More Save Options">"Save & Add New Instance otherwise, press "Save & Exit Form".

Questionnaire

Please complete the survey below.

Thank you!

Date and time of visit

Cohort ID

(i.e. "2_1")

Cluster ID is incorrect.

Structure ID

(Typing the ID shown on the structure. i.e, "malela-10-10")

First name

Middle name

Last name

This participant is available for the survey.

Please select the reason why the participant is not available.

Please indicate when he/she will be back. (If you do not know, please write 0.)

Specify the reason.

Did [name_f] spend any nights outside [name_f]'s house in the last four weeks?

Where did [name_f] spend those nights?

How many nights did [name_f] spend in another house in [name_f]'s village?

Did you see the ceiling nets in the household you visited in another house in the village?

☐ Yes
☐ No

How many nights did [name_f] spend in another village in Ndhiwa?

Did you see the ceiling nets in the household you visited in another village in Ndhiwa?

☐ Yes
☐ No

How many nights did [name_f] spend in Homa Bay County other than Mfangano and Mbita?

How many nights did [name_f] spend in another county in Kenya?

How many nights did [name_f] spend in another country?

Did [name_f] visit any health facility in the last four weeks?

☐ Yes
☐ No

(Please refer to the booklet)

Did [name_f] have the following symptoms at any point in the past four weeks?

- ☐ Fever
- ☐ Chills
- ☐ Profuse sweating
- ☐ Muscle/joint pain
- ☐ Abdominal pain
- ☐ Diarrhoea
- ☐ Nausea
- ☐ Vomiting
- ☐ Irritability
- ☐ Refusal to feed
- ☐ Prostration (difficulty to sit upright)
- ☐ Alteration in the level of consciousness
- ☐ Convulsions or coma
- ☐ Difficulty in breathing/respiratory distress
- ☐ Jaundice
- ☐ Others
- ☐ None

Please list other symptoms [name_f] experienced in the past four weeks.

How many times did the child visit health facilities?

- ☐ One time
- ☐ Two time
- ☐ Three time
- ☐ More than three

1

When did [name_f]visit the health facility?

2

3

4

5

(Please refer to the booklet)

6

7

Which health facility did [name_f] visit?

8

9

(Please refer to the booklet)

10

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☐ Malela level 4 hospital

☐ Kabongo HC

☐ Andiwo HC

☐ Wikomimo HC

☐ Abuoro HC

☐ Langi HC

☐ Kobodo HC

☐ Okok HC

☐ Other

17

Please state the health facility [name_f] visited.

18

19

20

Which symptoms did the child have?

21

22

(Please refer to the booklet)

23

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☐ Fever

☐ Headache

☐ Muscle pain

☐ Abdominal pain

☐ Nausea

☐ Vomiting

☐ Diarrhea

☐ Convulsions or coma

☐ Jaundice

☐ Rapid breathing

☐ Difficulty in breathing/respiratory distress

☐ Pale conjunctivae/palms

☐ Loss of reactivity

☐ Others

35

When did the symptom start?

36

37

38

39

(Please refer to the booklet)

40

41

Was [name_f] diagnosed with malaria?

42

43

(Please refer to the booklet)

44

45

☐ Yes

☐ No

46

What was the diagnosis?

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Did [name_f] take any treatment or medication?

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(Please refer to the booklet)

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What treatment or medication did [name_f] receive from the health facility?

(Please refer to the booklet)

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOT AL OR DHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER
- ☐ DON'TKNOW

Please list other medications [name_f] received from the health facility.

When did [name_f] FIRST visit the health facility?

(Please refer to the booklet)

Which health facility did [name_f] first visit?

(Please refer to the booklet)

- ☐ Malela level 4 hospital
- ☐ Kabongo HC
- ☐ Andiwo HC
- ☐ Wikomimo HC
- ☐ Abuoro HC
- ☐ Langi HC
- ☐ Kobodo HC
- ☐ Okok HC
- ☐ Other

Please state the health facility [name_f] visited.

Which symptoms did the child have at the first visit?

(Please refer to the booklet)

- ☐ Fever
- ☐ Headache
- ☐ Muscle pain
- ☐ Abdominal pain
- ☐ Nausea
- ☐ Vomiting
- ☐ Diarrhea
- ☐ Convulsions or coma
- ☐ Jaundice
- ☐ Rapid breathing
- ☐ Difficulty in breathing/respiratory distress
- ☐ Pale conjunctivae/palms
- ☐ Loss of reactivity
- ☐ Others

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When did the symptoms for the first visit start?

(Please refer to the booklet)

Was [name_f] diagnosed with malaria for the first visit?

Yes

No

(Please refer to the booklet)

What was the diagnosis?

Did [name_f] take any treatment or medication for the first visit?

Yes

No

(Please refer to the booklet)

What treatment or medication did [name_f] receive from the health facility?

AL

DHAP

OTHER ACT (NOT AL OR DHAP)

SP/FANSIDAR

CHLOROQUINE

AMODIAQUINE

QUININE (PILLS)

QUININE (INJECTION/IV)

ARTESUNATE (RECTAL)

ARTESUNATE (INJECTION/IV)

OTHER ANTIMALARIAL

AMOXICILLIN

COTRIMOXAZOLE

OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

ASPIRIN

PARACETAMOL/PANADOL/ACETAMINOPHEN

IBUPROFEN

OTHER

DON'TKNOW

(Please refer to the booklet)

Please list other medications [name_f] received from the health facility.

When did [name_f] SECOND visit the health facility?

(Please refer to the booklet)

Which health facility did [name_f] second visit?

Malela level 4 hospital

Kabongo HC

Andiwo HC

Wikomimo HC

Abuoro HC

Langi HC

Kobodo HC

Okok HC

Other

(Please refer to the booklet)

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Please state the health facility [name_f] visited.

Which symptoms did the child have at the second visit?

(Please refer to the booklet)

- ☐ Fever
- ☐ Headache
- ☐ Muscle pain
- ☐ Abdominal pain
- ☐ Nausea
- ☐ Vomiting
- ☐ Diarrhea
- ☐ Convulsions or coma
- ☐ Jaundice
- ☐ Rapid breathing
- ☐ Difficulty in breathing/respiratory distress
- ☐ Pale conjunctivae/palms
- ☐ Loss of reactivity
- ☐ Others

When did the symptoms for the second visit start?

(Please refer to the booklet)

Was [name_f] diagnosed with malaria for the second visit?

- ☐ Yes
- ☐ No

(Please refer to the booklet)

What was the diagnosis?

Did [name_f] take any treatment or medication for the second visit?

- ☐ Yes
- ☐ No

(Please refer to the booklet)

What treatment or medication did [name_f] receive from the health facility?

(Please refer to the booklet)

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOT AL OR DHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER
- ☐ DON'TKNOW

Please list other medications [name_f] received from the health facility.

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When did [name_f] THIRD visit the health facility?

(Please refer to the booklet)

Which health facility did [name_f] third visit?

☐ Malela level 4 hospital

☐ Kabongo HC

☐ Andiwo HC

☐ Wikomimo HC

☐ Abuoro HC

☐ Langi HC

☐ Kobodo HC

☐ Okok HC

☐ Other

Please state the health facility [name_f] visited.

Which symptoms did the child have at the third visit?

☐ Fever

☐ Headache

☐ Muscle pain

☐ Abdominal pain

☐ Nausea

☐ Vomiting

☐ Diarrhea

☐ Convulsions or coma

☐ Jaundice

☐ Rapid breathing

☐ Difficulty in breathing/respiratory distress

☐ Pale conjunctivae/palms

☐ Loss of reactivity

☐ Others

(Please refer to the booklet)

When did the symptoms for the third visit start?

(Please refer to the booklet)

Was [name_f] diagnosed with malaria for the third visit?

☐ Yes

☐ No

(Please refer to the booklet)

What was the diagnosis?

Did [name_f] take any treatment or medication for the third visit?

☐ Yes

☐ No

(Please refer to the booklet)

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1 What treatment or medication did [name_f] receive from
2 the health facility?

3
4 (Please refer to the booklet)

- 5 ☐ AL
6 ☐ DHAP
7 ☐ OTHER ACT (NOT AL OR DHAP)
8 ☐ SP/FANSIDAR
9 ☐ CHLOROQUINE
10 ☐ AMODIAQUINE
11 ☐ QUININE (PILLS)
12 ☐ QUININE (INJECTION/IV)
13 ☐ ARTESUNATE (RECTAL)
14 ☐ ARTESUNATE (INJECTION/IV)
15 ☐ OTHER ANTIMALARIAL
16 ☐ AMOXICILLIN
17 ☐ COTRIMOXAZOLE
18 ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
19 ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
20 ☐ ASPIRIN
21 ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
22 ☐ IBUPROFEN
23 ☐ OTHER
24 ☐ DON'TKNOW

25 Please list other medications [name_f] received from
26 the health facility.

27 Did [name_f] take treatment or medication from the
28 following in the past four weeks?

- 29 ☐ No
30 ☐ Friends
31 ☐ Relatives
32 ☐ Pharmacy/chemist
33 ☐ Traditional healers

34 What medications did [name_f] take from the friends?

- 35 ☐ AL
36 ☐ DHAP
37 ☐ OTHER ACT (NOT AL OR DHAP)
38 ☐ SP/FANSIDAR
39 ☐ CHLOROQUINE
40 ☐ AMODIAQUINE
41 ☐ QUININE (PILLS)
42 ☐ QUININE (INJECTION/IV)
43 ☐ ARTESUNATE (RECTAL)
44 ☐ ARTESUNATE (INJECTION/IV)
45 ☐ OTHER ANTIMALARIAL
46 ☐ AMOXICILLIN
47 ☐ COTRIMOXAZOLE
48 ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
49 ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
50 ☐ ASPIRIN
51 ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
52 ☐ IBUPROFEN
53 ☐ OTHER
54 ☐ DON'TKNOW

55 Please list other medications [name_f] took from the
56 friends.

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What medications did [name_f] take from the relatives?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

☐ DON'TKNOW

Please list other medications [name_f] took from the relatives.

What medications did [name_f] take from the pharmacy/chemist?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

☐ DON'TKNOW

Please list other medications [name_f] took from the pharmacy.

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What medications did [name_f] take from the traditional healer?

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOT AL OR DHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER
- ☐ DON'TKNOW

Please list other medications [name_f] took from the traditional healer.

Does [name_f] have the following symptoms now or in the last 24 hours?

- ☐ Fever
- ☐ Chills
- ☐ Profuse sweating
- ☐ Muscle/joint pain
- ☐ Abdominal pain
- ☐ Diarrhoea
- ☐ Nausea
- ☐ Vomiting
- ☐ Irritability
- ☐ Refusal to feed
- ☐ Prostration (difficulty to sit upright)
- ☐ Alteration in the level of consciousness
- ☐ Convulsions or coma
- ☐ Difficulty in breathing/respiratory distress
- ☐ Jaundice
- ☐ Others
- ☐ None

Please list other symptoms [name_f] experience now or in the last 24 hours.

Did [name_f] receive the malaria vaccine within four weeks?

- ☐ Yes
- ☐ No

How many times has [name_f] received the malaria vaccine, including the latest one?

- ☐ 1 dose
- ☐ 2 doses
- ☐ 3 doses
- ☐ 4 doses
- ☐ Don't know

Does the structure where [name_f] usually sleeps have ceiling nets?

- ☐ Yes
- ☐ No

Sample

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2 Please complete the survey below.
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4 Thank you!

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11 Cohort ID
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14 First name
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18 Middle name
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21 Last name
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24 Did you sleep under a bed net last night?
25 ☐ Yes
26 ☐ No
27
28 Axillary temperature (degrees Celsius)
29
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31 Perform finger prick
32 ☐ Yes
33 ☐ No
34
35 Blood spots on filter paper?
36 ☐ Yes
37 ☐ No
38
39 Thick and thin blood films?
40 ☐ Yes
41 ☐ No
42
43 RDT results for P.f
44 ☐ Negative
45 ☐ Positive
46
47 RDT results for Pan
48 ☐ Negative
49 ☐ Positive
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Participant questionnaire

Please complete the survey below.

Thank you!

Date and time of visit

Date and time of visit

Survey ID

(i.e. "s2_1")

Structure ID

(Typing the ID shown on the structure. i.e, "malela-10-10")

First name

Middle name

Last name

Age

(years old)

Does [name_f] know the birthday?

- ☐ Yes
☐ No

Birthday

The birthday and your age are contradicting. Please check the true age again.

Sex

- ☐ Male
☐ Female
☐ Other
☐ Prefer not to say

Longitude

Latitude

This participant is available for the survey.

- ☐ Yes
☐ No

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Please select the reason why the participant is not available.

☐ Moved out from the area (will never come back)

☐ Travel to another village in Ndhiwa

☐ Travel to Homa Bay County other than Ndhiwa

☐ Travel to Another county in Kenya

☐ Travel to Another country

☐ Refuse

☐ Do not know (Could not find)

☐ Others

Specify the reason.

Did [name_f] spend any nights outside [name_f]'s house in the last four weeks?

☐ Yes

☐ No

Where did [name_f] spend those nights?

☐ Another house in your village

☐ Another village in Ndhiwa

☐ Homa Bay County other than Ndhiwa

☐ Another county in Kenya

☐ Another country

How many nights did [name_f] spend in another house in [name_f]'s village?

Did you see the ceiling nets in the household you visited in another house in the village?

☐ Yes

☐ No

How many nights did [name_f] spend in another village in Ndhiwa?

Did you see the ceiling nets in the household you visited in another village in Ndhiwa?

☐ Yes

☐ No

How many nights did [name_f] spend in Homa Bay County other than Ndhiwa?

How many nights did [name_f] spend in another county in Kenya?

How many nights did [name_f] spend in another country?

Did [name_f] have any symptoms at any point in the past four weeks?

☐ Yes

☐ No

☐ Don't know

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What was the symptom? Tick all that apply.

- ☐ Fever
- ☐ Chills
- ☐ Profuse sweating
- ☐ Muscle/joint pain
- ☐ Abdominal pain
- ☐ Diarrhoea
- ☐ Nausea
- ☐ Vomiting
- ☐ Irritability
- ☐ Refusal to feed
- ☐ Prostration (difficulty to sit upright)
- ☐ Alteration in the level of consciousness
- ☐ Convulsions or coma
- ☐ Difficulty in breathing/respiratory distress
- ☐ Jaundice
- ☐ Cough
- ☐ Rash
- ☐ Itches
- ☐ Others

Please list other symptoms [name_f] experienced in the past four weeks.

Did [name_f] visit any health facility in the last four weeks?

- ☐ Yes
- ☐ No

Which health facility did [name_f] visit?

- ☐ Malela level 4 hospital
- ☐ Kabongo HC
- ☐ Andiwo HC
- ☐ Wikomimo HC
- ☐ Abuoro HC
- ☐ Langi HC
- ☐ Kobodo HC
- ☐ Okok HC
- ☐ Other

Please state the health facility [name_f] visited.

Was [name_f] diagnosed with malaria?

- ☐ Yes
- ☐ No

What was the diagnosis?

Did [name_f] take any treatment or medication?

- ☐ Yes
- ☐ No

Do you know the name of the medication?

- ☐ Yes
- ☐ No

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What treatment or medication did [name_f] receive from the health facility?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

Please list other medications [name_f] received from the health facility.

Did [name_f] take treatment or medication from friends, relatives, pharmacy/chemist, or traditional healers in the past four weeks?

☐ Yes

☐ No

Did [name_f] take treatment or medication from the following in the past four weeks?

☐ Friends

☐ Relatives

☐ Pharmacy/chemist

☐ Traditional healers

Do you know the names of medications from your friends?

☐ Yes

☐ No

What medications did [name_f] take from the friends?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

Please list other medications [name_f] took from the friends.

Do you know the names of medications from your relatives?

☐ Yes

☐ No

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What medications did [name_f] take from the relatives?

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOT AL OR DHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER

Please list other medications [name_f] took from the relatives.

Do you know the names of medications from the pharmacy/chemist?

- ☐ Yes
- ☐ No

What medications did [name_f] take from the pharmacy/chemist?

- ☐ AL
- ☐ DHAP
- ☐ OTHER ACT (NOT AL OR DHAP)
- ☐ SP/FANSIDAR
- ☐ CHLOROQUINE
- ☐ AMODIAQUINE
- ☐ QUININE (PILLS)
- ☐ QUININE (INJECTION/IV)
- ☐ ARTESUNATE (RECTAL)
- ☐ ARTESUNATE (INJECTION/IV)
- ☐ OTHER ANTIMALARIAL
- ☐ AMOXICILLIN
- ☐ COTRIMOXAZOLE
- ☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)
- ☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)
- ☐ ASPIRIN
- ☐ PARACETAMOL/PANADOL/ACETAMINOPHEN
- ☐ IBUPROFEN
- ☐ OTHER

Please list other medications [name_f] took from the pharmacy.

Do you know the names of medications from the traditional healer?

- ☐ Yes
- ☐ No

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What medications did [name_f] take from the traditional healer?

☐ AL

☐ DHAP

☐ OTHER ACT (NOT AL OR DHAP)

☐ SP/FANSIDAR

☐ CHLOROQUINE

☐ AMODIAQUINE

☐ QUININE (PILLS)

☐ QUININE (INJECTION/IV)

☐ ARTESUNATE (RECTAL)

☐ ARTESUNATE (INJECTION/IV)

☐ OTHER ANTIMALARIAL

☐ AMOXICILLIN

☐ COTRIMOXAZOLE

☐ OTHER ANTIBIOTIC MEDICINE (PILL/SYRUP)

☐ OTHER ANTIBIOTIC MEDICINE (INJECTION/IV)

☐ ASPIRIN

☐ PARACETAMOL/PANADOL/ACETAMINOPHEN

☐ IBUPROFEN

☐ OTHER

Please list other medications [name_f] took from the traditional healer.

Does [name_f] have any symptoms now or in the last 24 hours?

☐ Yes

☐ No

Does [name_f] have the following symptoms now or in the last 24 hours?

☐ Fever

☐ Chills

☐ Profuse sweating

☐ Muscle/joint pain

☐ Abdominal pain

☐ Diarrhoea

☐ Nausea

☐ Vomiting

☐ Irritability

☐ Refusal to feed

☐ Prostration (difficulty to sit upright)

☐ Alteration in the level of consciousness

☐ Convulsions or coma

☐ Difficulty in breathing/respiratory distress

☐ Jaundice

☐ Cough

☐ Rash

☐ Itches

☐ Others

Please list other symptoms [name_f] experience now or in the last 24 hours.

Has [name_f] received a malaria vaccine?

☐ Yes

☐ No

Please refer to the mother-child book.

How many times has [name_f] received the malaria vaccine?

☐ 1 dose

☐ 2 doses

☐ 3 doses

☐ 4 doses

☐ Don't know

Please refer to the mother-child book.

Does the structure where [name_f] usually sleeps have ceiling nets?

☐ Yes

☐ No

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Sample

Please complete the survey below.

Thank you!

Survey ID

First name

Middle name

Last name

Did you sleep under a bed net last night?

- ☐ Yes
- ☐ No

Axillary temperature (degrees Celsius)

Perform finger prick

- ☐ Yes
- ☐ No

Blood spots on filter paper?

- ☐ Yes
- ☐ No

Thick and thin blood films?

- ☐ Yes
- ☐ No

RDT results for P.f

- ☐ Negative
- ☐ Positive

RDT results for Pan

- ☐ Negative
- ☐ Positive

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Head questionnaire

Please complete the survey below.

Thank you!

Who is the respondent?

☐ Head

☐ Primary care taker

☐ Participant

☐ Others

*If the respondent are not sure about the answer(s), he/she can be helped by the other members.

What is the respondent's relation to the participant?

☐ Head

☐ Spouse (Husband or wife 1)

☐ Wife 2 or 3

☐ Parent

☐ Parent in law

☐ Child

☐ Child in law

☐ Brother/Sister

☐ Brother/Sister in law

☐ Grand Child

☐ Nephew/Niece

☐ Uncle/Aunt

☐ Worker

☐ Other relative

☐ Other non-relative

What is the condition of the ceiling net?

☐ No damage

☐ Damaged and not repaired

☐ Damaged but repaired

☐ Removed

☐ Not installed

How many hole(s) does/did it have?
(regardless of the size)
(mark 0 if no hole)

Where are the hole(s) located?

☐ Around the edge (lower part, near the wall)

☐ Around the top

☐ In the middle

What is/was the size of largest hole?

☐ smaller than the tip of index finger

☐ smaller than the fist

☐ larger than the fist

What is/was the reason of the damage?

☐ Accident during the cleaning

☐ Animal

☐ Caught a fire

☐ Unknown

☐ Others

Please specify the reason of the damage

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Why did they remove?

What is the condition of the wooden battens securing the ceiling net to the wall?

- ☐ Good
☐ Damaged

Presence of gaps between battens and the wall

- ☐ Yes
☐ No

Do you agree with the following potential positive sides of the ceiling net?

- ☐ Stop mosquito entering the house
☐ Stop other insects/animals entering the house
☐ Durability of the ceiling nets
☐ To beautify the house
☐ Household coverage
☐ Keep the room cool
☐ Others

Please specify.

Do you agree with the following potential negative sides of the ceiling net?

- ☐ It makes room too hot
☐ It reduces the storage space at the top of the wall
☐ Fixing looks untidy
☐ It is hard to clean
☐ Dirt/debris trapped by the ceiling net
☐ Rewiring of power lines
☐ Others

Please specify.

Other features in the ceiling net (if any).

Will you pay for the ceiling nets if you need to buy them in the future?

- ☐ Yes
☐ No

How much will you pay the maximum for ceiling nets for your household?

- ☐ 100 KSH
☐ 300 KSH
☐ 500 KSH
☐ 1000 KSH
☐ 2000 KSH
☐ 5000 KSH
☐ More than 10,000 KSH

How many mosquito nets does your household have?

How many new (unopened) mosquito nets does your household have?

Does anyone in your household wash the mosquito nets?

- ☐ Yes
☐ No

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How often does your household wash the mosquito nets?

☐ Every day

☐ Every week

☐ Every month

☐ less frequently than every month

How does your household wash the mosquito nets?

☐ With water

☐ With hot water

☐ With soap or detergent

☐ Others

How does your household dry the mosquito nets after washing it?

☐ Indoor

☐ Under the sunlight

☐ Under the shade

☐ Others

Have you ever gotten any instruction on how to use and treat the mosquito net?

☐ Yes

☐ No

From who did you get the instruction?

In general, how long can you use the bed net effectively?

☐ One year even without damages

☐ Three years even without damages

☐ Ten years even without damages

☐ Until it gets damaged

Do you agree the mosquito net contains some drugs against mosquitoes?

☐ Yes

☐ No

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