Effectiveness of The Innovative 1,7-Malaria Reactive Community-based Testing and Response (1, 7-mRCTR) Approach on Malaria Burden Reduction in Southeastern Tanzania

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Research

Keywords: Malaria, 1,7-mRCTR approach, community-based, testing, and response, health facilities, control, and intervention.

Posted Date: June 2nd, 2020

DOI: https://doi.org/10.21203/rs.3.rs-32068/v1

Version of Record: A version of this preprint was published on August 14th, 2020. See the published version at https://doi.org/10.1186/s12936-020-03363-w.

Abstract

Background: In 2015, a China-UK-Tanzania tripartite pilot project was implemented in south-eastern Tanzania to explore a new model for reducing malaria burden and possibly scaling-out the approach into other malaria endemic countries. The 1,7-malaria Reactive Community-based Testing and Response (1,7-RCTR) which is a locally-tailored approach for reporting febrile malaria cases in endemic villages was developed to stop transmission and plasmodium life-cycle. The (1,7-RCTR) utilizes existing health facility data and locally trained community health workers to conduct community-level testing and treatment.

Methods: The pilot project was implemented from September 2015 to June 2018. Matched malaria incidence pairs of control and intervention wards were chosen. The latter arm was selected for the 1,7-mRCTR approach leaving control wards relying on existed programs. The 1,7-mRCTR activities included community testing and treatment of malaria infection. Malaria case-to-suspect ratios at health facilities (HF) were aggregated by villages, weekly to identify the village with the highest ratio. Community-based mobile test stations (cMTS) were used for conducting mass testing and treatment. Random household surveys were done in the control and intervention wards before (baseline) and after (endline) the program. The primary outcome was the baseline and endline difference of malaria prevalence in the control and intervention wards measured by the interaction term of 'time' (post vs. pre) and group in a logistic model. We also studied the malaria incidence reported at the health facilities during the intervention.

Results: Overall 85 rounds of 1,7-mRCT conducted in the intervention wards significantly reduced the odds of malaria infection by 66% (adjusted OR 0.34, 95%CI 0.26,0.44, p<0001) beyond the effect of the standard programs. Malaria prevalence in the intervention wards declined by 81% (from 26% (95% CI, 23.7, 7.8), at baseline to 4.9% (95% CI, 4.0,5.9) at endline). Villages receiving the 1,7-mRCT had a case ratio decreased by over 15.7% (95%CI, -33, 6) compared to baseline.

Conclusion: The 1,7-mRCTR approach reduced significantly the malaria burden in the areas of moderate and high transmission in southern Tanzania. This locally-tailored approach could accelerate malaria control and elimination efforts. The results provide the impetus for further evaluation of the effectiveness and scaling up of this type of approach in other high malaria burden countries in Africa, including Tanzania.

Background

In recent decades, there has been a substantial increase in financial and political commitment supporting the fight against malaria. Specifically, investments have gone into the scaling-up of vector control tools such as long-lasting insecticidal net (LLINs) and indoor residual spraying (IRS) [1–6]. Additionally, significant improvements have been made in case management by the introduction of artemisinin-based combination therapy (ACT) [7, 8]. Such interventions have produced a massive reduction in the malaria burden and prevented several million deaths worldwide [1, 9, 10]. Globally, it is estimated that 228 million

malaria cases were reported in 2018, with Africa bearing the brunt of this burden [1]. Malaria control spans over decades in Tanzania, with a national scale-up of preventive strategies and improved quality and access to testing and treatment [8, 11, 12]. As a result, the prevalence has declined from an average of 18.1% in 2008 to 7.3% in 2017 [13, 14]. Despite these notable achievements, the fight is far from over. More than 93% of the Tanzania population remains at risk of malaria [11, 13]. Sustaining the gains and making progress towards elimination remain the main challenges owing to financial gaps to ensure universal coverage, access to health services, and epidemiological challenges.

To guide malaria elimination, the World Health Organization (WHO) has released the *Global Technical Strategy for Malaria 2016–2030*, which emphasizes the importance of transforming the malaria surveillance response strategy into a core intervention [15]. The national malaria control program (NMCP) takes into account the epidemiology and diversity of malaria in each country using malaria burden stratification and tailoring interventions to the local context [16–18]. Likewise, WHO's Test -Treat-Track (T3) [19] initiative for malaria surveillance and the response has been in place to guide the goals of universal coverage of preventive tools and eliminating malaria deaths and eradicating the disease. In China professionals have developed surveillance and response systems with the timeline for tracking the infectious sources, namely the “1-3-7” approach [20, 21]. Confirmed cases must be reported within 1 day, origin (imported or domestic) determined within 3 days, and appropriate intervention to reduce the chance of onward transmission must be done within 7 days. This approach has been used in China’s national malaria elimination programme [22]. Several studies have shown that targeted interventions could hasten malaria elimination [23–27]. However, the question remains open regarding what epidemiological characteristics are applicable and what would be the best model to introduce targeted malaria intervention in higher-incidence settings.

In Tanzania, a review of the most recent population-based malaria indicator survey and of health facility information has shown the high heterogeneity of malaria endemicity within regions across the country [11, 28–31], underscoring the need to carefully deploy appropriate interventions. New approaches for malaria control are needed to sustain and accelerate progress towards elimination, and the combination of the WHO-T3 initiative and the Chinese experience of surveillance and response offers a great opportunity for the identification of new approaches.

The main objectives of the China-UK-Tanzania tripartite pilot project were (i) to reduce the malaria burden by 30% in 2018 compared to that of 2015; (ii) to strengthen the capacity of malaria control at the local level; and (iii) to explore the appropriate model and mechanism to develop scalable antimalarial programs for Tanzania and other African countries. Taking the cues from China’s domestic success and the WHO-T3 initiative, the Chinese and Tanzanian teams jointly developed a new approach for malaria surveillance and response. The 1,7-mRCTR approach operates at the village level and entails reporting of any confirmed malaria cases at the health facilities (HFs) within 24 hours combined with a follow-up the next week consisting of focal treatment of holoendemic villages to stop transmission at the same phase of the plasmodium life-cycle. This targeted approach aligns with WHO’s high-impact initiative for countries with moderate and high transmission, tailoring the Chinese experiences and WHO-T3 initiative

into the local settings of Tanzania [32]. The overriding objective was to compare the 1,7-mRCTR approach by observing changes of the malaria prevalence, comparing changes from baseline in the intervention and control wards, in areas where the burden of malaria infection is high. As a secondary objective, we also studied the changes in malaria incidence reported at the health facilities after interventions in the villages.

Methods

Study design and setting

The study area was the Rufiji District, located in southern Tanzania which has been previously described [33, 34]. A pilot project was implemented from September 2015 to June 2018. Two control wards (Bungu and Kibiti) and two intervention wards (Chumbi and Ikwiriri) were selected. Based on the malaria incidence rates recorded the preceding year by staff at the local HFs, each arm contained one high-transmission and one moderate transmission-ward. Since these wards (except Chumbi) had been part of the previous Health and Demographic Surveillance System site (HDSS), they were considered well prepared for testing and treatment evaluation of the proposed model under program conditions [35]. The two control wards received no interventions beyond what was provided by the NMCP, primarily LLINs. Fourteen facilities were located in the control wards, eight in Bungu and six in Kibiti, but only one per ward was a proper health center, the others being dispensaries. The intervention wards contained eleven HFs covering eighteen villages, again with one proper health center per ward, and the rest being dispensaries. Nearly 89% of the people in Rufiji live within 5 km of an HF [36]. The approximate distance between the centers of Ikwiriri (intervention ward) and Kibiti (control ward) was 30 km. Based on the census of 2012, the total populations of the intervention and control wards in 2012 were 72,163 and 53,292, respectively [37]. The average household size in Rufiji was 4.4, and 45% of the total population was under 15 years of age [37]. Figure 1 shows a map of the study area with the location of the pilot project wards.

Statistical analysis

Baseline and endline prevalences were computed as the values of the intercepts in generalized estimating equations (GEE) clustering on household and using the identity link, with their standard errors. Univariate analyses were done to test the relationships between different potential explanatory variables and prevalent malaria. Comparisons between the intervention and control arms were done similarly for each survey. Malaria prevalence was modeled using generalized estimating equations (GEEs) with the logit link, clustering at the household level. The effect of 1,7-mRCTR was estimated by comparing the changes from the baseline malaria prevalence to that at the endline surveys (main effect ‘time’) in the two areas (main effect ‘area’), using the interaction term of area and ‘time’ (baseline vs. endline) as the measure of program effect (difference-of-differences). When the interaction effect is included in the model, the main effect of area describes the difference between the two areas at baseline, and the main effect of time gives the ‘average’ change in odds of malaria from baseline to endline. The interaction effect represents the difference between the changes in the two areas.

Categorical variables were presented as numbers (percentages), while continuous variables were presented as mean (confidence interval)/medial (quartile range), respectively. Potential confounders included age (categorized as less than 5 years, 5 to 14 years and above 15 years), sex, LLINs use in the previous night, and socio-economic status (SES). The wealth index (SES) as a potential risk factor for malaria infection, was generated using principal component analysis on a list of assets possessions to produce the SES quintiles [40].

For the duration of the project, routine data were available only for the intervention wards, and the only routinely collected case-related numbers were in HFs. Therefore, we had to analyze the case ratios (HFs cases/population) rather than true incidence values. A mixed-effects regression model with village as a random effect was used to analyze the impact of the 1,7-mRCTR in reducing health facility attendance between villages receiving malaria intervention and those not receiving it. The detailed analytical procedure for the health facility data analysis is described in the SM. Statistical analyses were performed using STATA software (version 15.1, College Station, TX, USA) and SAS software (version 9.4, Cary, NC, USA).

Implementation

Before the study began, formal meetings were held between the researchers, the District Medical Officer's (DMO's) office, the Council Health Management Team (CHMT) staff, and local community leaders to discuss the study objectives, procedures, and timelines. Accompanying printed materials in the *Swahili* language were distributed at this meeting to provide complementary project information. To maximize project acceptance after a village had been identified as a hotspot, weekly social mobilizations were initiated, i.e. the field supervisor and village community leaders held meetings to discuss the logistics and community-based mobile test stations (cMTS) locations. Upon deciding on the locations, village leaders and CHCWs informed the rest of community members about the presence of the cMTS, emphasizing that testing and treatment were free. Although only the 'hotspot villages' were targeted, people from neighboring villages who came for testing were also tested and treated. When a village reappeared as a hotspot, test station locations were chosen using information based on the previous time(s) of response. Village members above six months of age were invited to be screened for malaria. This was done with an ICT® rapid diagnostic test (CareStartTM Malaria Pf/PAN (HRP2/pLDH) Ag Combo RDT), and malaria positive cases were treated with dihydroartemisinin-piperaquine (D-ARTEPP) following the national policy guidelines for malaria treatment [38]. Due to security problems in the study area, the activities stopped for eight months from January to August 2017 and resumed from September 2017 to April 2018. The detailed activities for the 1,7-mRCTR implementation are provided in Supplementary material (SM).

Evaluation

The primary measure of the effectiveness of 1,7-RCTR, determined in advance, was the adjusted comparison of the changes in malaria prevalence from before the project to after the intervention in the

control and intervention areas. Baseline and endline household cross-sectional surveys with independent samples were conducted in both intervention and control areas. Figure 2 shows the schematic summary of the study design and implementation of the 1,7-mRCTR model in the study area.

The baseline was created using data collected from September to November 2015, with the endline survey done from February to April 2018. A random sample of 2000 households was selected based on community census data for each of the baseline and endline surveys. A structured questionnaire was designed based on the standard RBM-MERG malaria indicator survey tool [39]. It was developed in English, translated into *Swahili*, and installed on tablets using the Open Data Kit software. A full description of the study's aim and the objective was given to the head of the household at the first visit. All participants were provided with a written informed consent form describing the risks, benefits, and the participant's rights to free diagnosis and treatment. The right to refuse participation without penalty was explained and guaranteed. If a household in the list could not be located or did not wish to participate, a nearby house with similar features was selected for replacement. At the household level, each occupant was tested *in situ* for parasite infection using an RDT, blood smear, and filter papers. For the analysis presented in this paper, only RDT results were considered. The detailed method for the baseline survey has been reported previously [33].

Results

Community impact of 1,7-mRCTR on the reduction of malaria prevalence

Overall 9,522 and 10,134 participants were surveyed during the baseline and endline surveys, respectively. A total of 7,691 and 7,989 individuals agreed to provide fingerpick blood for malaria testing for each respective survey (Table 1). The median household size for the baseline and endline survey population was 6 (interquartile range IQR, 4–8) and 5 (IQR, 4–7), respectively. All age groups were included in the study, and people ≥ 15 years of age accounted for more than 52% of all participants, followed by the 5–15 years age group (31%). In both surveys, females accounted for 55% of the total surveyed participants. The disease burden recorded in both intervention and control wards at the baseline survey significantly declined by the time of the endline survey. Malaria prevalence in the intervention wards declined by 81% (from 26.0% (95% CI, 23.7–27.8), at the baseline to 4.9% (95% CI, 4.0-5.9) at the end of the study) (Table 1). In the control wards, malaria prevalence was reduced by 52% (from 28.1% (95% CI, 26.1–30.2) at the baseline to 13.4% (95% CI, 12, 12-14.7) at the endline survey. Both intervention and control wards showed a significant increase in LLINs use over the time of the study as a whole. In the intervention wards, the use of LLINs increased from 66% (95% CI, 62.6–69.1) at the baseline to 83% (95% CI, 81.3–85.3) at the final survey. In the control wards, use of LLINs increased from 49.4% (95% CI, 46.4–52.4) at the baseline survey to 80% (95% CI, 77.9–81.5) at the end.

Table 1
Demographic and characteristics of participants in the baseline and endline community surveys

	Baseline survey		Endline survey	
Characteristics	**Control**	**Intervention**	**Control**	**Intervention**
Population*, n (%)	4867	4685	5728	4406
Age group, years				
< 5	908 (18.7%)	852 (18.2%)	986 (17.2%)	702 (15.9%)
5–15	1602 (32.9%)	1425 (30.4%)	1727 (30.2%)	1307 (29.7%)
> 15	2357 (48.4%)	2408 (51.4%)	3015 (52.6%)	2397 (54.4%)
Sex, n (%)				
Female	2698 (55.4%)	2509 (53.6%)	3310 (57.8%)	2464 (55.9%)
Male	2169 (44.6%)	2176 (46.4%)	2418 (42.2%)	1942 (44.1%)
Malaria infection[1], n (%, 95% CI)				
Positive	1103 (28.1, 26.1–30.2)	967 (25.7, 23.7–27.8)	621 (13.4, 12.12–14.7)	163 (4.9, 4.0-5.9)
Negative	2827 (71.9, 69.9–73.9)	2794 (74.3, 72.2–76.3)	4029 (86.6, 85.3–87.9)	3176 (95.1, 94.1–96.0)
Bednet use[2], n (%, 95% CI)				
Yes	2316 (49.4, 46.4–52.4)	2969 (65.9,62.6–69.1)	4568 (79.7, 77.9–81.5)	3673 (83.4, 81.3–85.3)
No	2375 (50.6, 47.6–53.6)	1534 (34.1,30.9–37.4)	1160 (20.3, 18.5–22.2)	733 (16.6, 14.7–18.7)

*Number of individuals surveyed; [1]based on malaria rapid testing using RDT; [2]Reported insecticide-treated bednet uses the previous night.

Multivariate analysis

Multivariate analysis using GEEs is presented in Table 2. The baseline malaria prevalence was lower in the intervention wards adjusted odds ratio (aOR) 0.41 (95% CI 0.35–0.48, p < 0.001), and both wards had much lower odds of malaria at endline compared to baseline aOR 0.90 (95% CI 0.77–1.04, p = 0.14)

(Table 2). The adjusted odds ratio (aOR) of the endline/baseline was 0.34 (95% CI 0.26–0.44, $p < 0.001$). The decline in prevalence odds in the intervention wards was much greater than that in the control wards. LLIN use was associated with significantly lower odds of having malaria: aOR 0.71(95% CI 0.63–0.80). The highest wealth quintiles (i.e. those better off) people were less likely to be infected by malaria, aOR 0.21 (95% CI 0.17–0.26, $p < 0.001$)) as compared to the lowest (i.e. the poorest). The 5–15 years old participants had twice as high odds of malaria infection compared to those under five, aOR 2.13 (95% CI 1.89–2.40, $p < 0.001$)) (Table 2).

Table 2
Univariate and multivariable analysis describing the effects of the 1,7-mRCTR and risk factors for malaria infection

Variables	Univariable model		Multivariable model	
	cOR(95% CI)	p-value	aOR((95% CI)	p-value
Survey years				
Baseline	1(ref)	–	1(ref)	–
Endline	0.29(0.26–0.33)	< 0.001	0.41(0.35–0.48)	< 0.001
Site				
Control wards	1(ref)	–	1(ref)	–
Intervention wards	0.74(0.66–0.84)	< 0.001	0.90(0.77–1.04)	0.14
Comparison of endline to baseline				
Control	1(ref)	–	1(ref)	–
Intervention	0.17(0.14–0.21)	< 0.001	0.34(0.26–0.44)	< 0.001
Sex				
Female	1(ref)	–	1(ref)	–
Male	1.44(1.32–1.57)	< 0.001	1.24(1.13–1.36)	< 0.001
Age group, years				
< 5 years	1(ref)	–	1(ref)	–
5–15 years	2.09(1.87–2.34)	< 0.001	2.13(1.89–2.40)	< 0.001
> 15 years	0.67(0.60–0.76)	< 0.001	0.67(0.59–0.76)	< 0.001
Bednet use[1]				
No	1(ref)	–	1(ref)	–
Yes	0.43(0.38–0.48)	< 0.001	0.71(0.63–0.80)	< 0.001
Wealth index				
Lowest	1(ref)	–	1(ref)	–
Second	0.86(0.74–1.02)	0.076	0.75(0.64–0.88)	< 0.001
Middle	0.62(0.52–0.73)	< 0.001	0.56(0.47–0.66)	< 0.001

cOR = crude odds ratio; aOR = adjusted odds ratio; CI = confidence interval; [1]Insecticide-treated bednet use previous night.

Variables	Univariable model		Multivariable model	
Fourth	0.55(0.46–0.65)	< 0.001	0.50(0.42–0.60)	< 0.001
Highest	0.23(0.19–0.29)	< 0.001	0.21(0.17–0.26)	< 0.001

cOR = crude odds ratio; aOR = adjusted odds ratio; CI = confidence interval; [1]Insecticide-treated bednet use previous night.

Changes noted in the intervention communities

The Chumbi high-transmission ward had a total population of 26,631 people (per census), with 15,317 malaria cases (reporting to the HF) during the study period. The Ikwiriri moderate-transmission ward had a total population of 45,532 people (per census), with 21,254 reported HF malaria cases (Table 3). The average case ratios (total number of positive cases per total population) were 5.34 and 4.38 (per 1,000 population per week) for Chumbi and Ikwiriri, respectively. While both wards had roughly the same case ratio in the low transmission season (August-April), they diverged in the high transmission season (May-July), with a more considerable increase in Chumbi. A total of 50 rounds of 1,7-mRCTR visits were conducted in Chumbi, during which 6,511 cases were treated. In the Ikwiriri ward, 35 rounds of 1,7-mRCTR visits were conducted, with 2,924 cases treated. The median age of the participants subjected to the 1,7-mRCTR rounds was 15 years (IQR, 7–28). One village never received a 1,7-RCTR. No important adverse reactions were reported during the study period.

There was a substantial decrease in weekly case ratios per 1,000 population from 2016 to 2017 during both the low and the high season (Table 3). Weekly case ratios from 2016 to 2017 decreased proportionately more in the low season (Table 3). In Ikwiriri, the case ratio during the high season barely decreased at all (6.5–6.0%,), while in Chumbi the case ratio decreased proportionately less in the high season (8.4–6.8%, a 19.4% decrease) than in the low season (4.0–2.2%, a 45% decrease).

Table 3
Characteristics of participants screened and number of health facility cases and case ratios by ward, season and year during the 1,7-mRCTR project in the intervention wards

Characteristics	Moderate-transmission ward (Ikwiriri)	High-transmission ward(Chumbi)	Overall
Total population, n	45532	26631	72163
Number of treatment rounds	35	50	85
Population screened	17160	21246	38406
Malaria infection (%)*	2924 (17.0)	6511 (30.6)	24.57
Fraction of village population tested (mean (standard error))	10.5 (1.3)	12.0 (1.7)	11.4(1.1)
Fraction of those tested who were positive	17.5 (1.7)	31.8 (2.6)	25.9(1.8)
Total number of health facility cases, n	21254	15317	36571
Number of health facility cases, (n (Weekly case ratio/1000 popn) (%))			
Low transmission season[$] 2016	7728 (4.47)	5180 (3.96)	12908(4.25)
2017	5578 (3.22)	2825 (2.16)	8403(2.77)
High transmission season [$$] 2016	4127 (6.47)	4049 (8.40)	8176(7.30)
2017	3821 (5.99)	3263 (6.77)	7084(6.33)

*Tested positive for malaria infection by RDT; [$]September to April, [$$]May to August, popn = population, std err = standard error

Changes in reported malaria cases at the village level

A mixed-effect regression model analysis of the routine health facilities data controlling for the season, wards, their interaction and number of times the village was previously treated indicated that in the week after a 1,7-mRCTR visit in the village, the case ratio decreased by over 15.7% (95% CI, -33,6) but was not significant (Table 4).). From 2 to 5 + weeks after village treatment, the case ratio varied between weeks but was mostly below that during the week of treatment. The analysis separating the two intervention wards (Chumbi and Ikwiriri) showed the same trend of low-level case ratio reductions.

Table 4
Estimated change in malaria incidence case ratios compared to the 'hotspot' week, by week after 1-7RCTR response in the village of the intervention wards

Weeks since treatment	Exchangeable model			
	Estimate %	95% CI		p-value
	Ref			
Week of treatment	13.6	-7.1	38.9	0.22
Week following treatment	-15.7	-33.0	5.9	0.14
2 weeks after treatment	-3.1	-24.5	24.3	0.80
3 weeks after treatment	5.3	-17.9	35	0.69
4 weeks after treatment	9	-18.5	45.8	0.56
5–13 weeks after treatment	8.7	-7.1	27.2	0.30

*Based on a mixed model, weighted by the inverse probability of being in the designated week of or after the 1,7-mRCTR and controlling for ward, season, time since the beginning of the project.

Discussion

The China-UK-Tanzania malaria project was the first attempt to look at the adaptability and the feasibility of 'operationalizing' Chinese experiences for malaria control in African settings. Despite successful domestic malaria control in China, the combination of WHO-T3 initiative and the Chinese "1-3-7" approach and tailor to Tanzania settings required far more resources than were available. Therefore, the project needed some simple adaptions, such as the inclusion of parameters allowing isolation (in the village of residence) of cases testing positive and the development of an electronic platform for individual case reports. The modified approach was able to capture all HF cases daily and launch a next-week response by the team of community-based health workers (CHCWs). The 1,7-mRCTR approach successfully deployed cMTS served by local community-based personnel, including field interviewers, nurses, laboratory technicians, and clinicians. Thus, considering the local malaria situation, the 1,7-mRCTR approach has demonstrated the strength and capability to create and deliver a novel approach for fast-track elimination of malaria in African endemic countries.

The 1,7-mRCTR intervention demonstrated a substantial impact in reducing the malaria burden in the areas characterized by moderate to high malaria transmission in south-eastern Tanzania. The dramatic reduction in the intervention wards (81%) compared to the control areas (52%) produced clear and practical evidence underlining the usefulness of the 1,7-mRCTR intervention, which was bolstered by the multivariate analysis showing that the reduction of the malaria prevalence (66%) was beyond the impact of LLINs alone. Importantly, current malaria interventions, including the most advanced ones using the novel vaccination approach, have only reported a 30–50% effect beyond that of LLIN use [41].

The results are consistent with previous studies demonstrating the effect of early diagnosis and community treatment in reducing the burden of malaria infection in SSA countries and elsewhere [25, 42–44]. However, contrary to these studies, the 1, 7-RCTR for screening and treatment was based on using a village as the index of observation and evaluation instead of individuals. The advantage of this approach was that it provided a chance for all community members to participate, which is in line with the current WHO-recommended focus and strategy on the high burden and high impact [32]. Also, the fact that the 1,7-mRCTR involved the local CHCWs provides a strong foundation for the sustainability of addressing the essential systemic key issue to project implementation. Moreover, the 1,7-mRCTR contributed to the collection of data on malaria from all health facilities by local CHCWs to identify weekly priority areas for screening and treatment. The achieved reduced malaria burden using the 1,7-mRCTR approach highlights the opportunity of using HF data to improve access to prompt, effective malaria treatment, especially in remote, underserved areas with moderate-high malaria transmission [41, 45, 46]. Likewise, the use of CHCWs can also help optimize the coverage of the intervention and improve awareness of the disease, as most of the CHCWs are from the project area and know the geographical settings well. Unlike experiences in similar projects with children having diarrhea, fever, or non-severe pneumonia in Zambia and Uganda [47, 48], we did not demonstrate a decrease of care-seeking

The findings from this study are limited in terms of spatial and temporal coverage. The project was implemented in only one district of the country, which has several other settings with varying epidemiological, ecological, socio-economic, and cultural. There is still a need to further explore whether this intervention package would lead to similar results in other areas, which are epidemiologically, ecologically, and socio-economically different. Extending this intervention in other settings would help ascertain the findings of the pilot project and further build confidence in possible uptake by national programs and subsequently scale-up for impact. Indeed, the 1,7-mRCTR could potentially be an innovative and effective approach to accelerate malaria elimination in Africa, however, this assertion is based on the epidemiological impact assessment of the intervention only.

Conclusion

Implementation of the 1,7-mRCTR contributed convincingly to the reduction of the malaria burden in areas of moderate and high transmission in Southern Tanzania. The results encourage a broader evaluation of the 1,7-mRCTR approach and the strategic approaches for accelerating efforts toward malaria control and elimination. Furthermore, lessons learned from the implementation of the 1,7-mRCTR approach with the community-based capacity building and local health system strengthening are shaping the Chinese aid efforts to support African countries in accelerating malaria control and elimination.

List Of Abbreviations

1,7-mRCTR- 1,7- malaria Reactive Community-based Testing and Response

cMTS- Community-based mobile test station

SSA- sub-Saharan Africa

WHO- World Health Organisation

RDT- malaria rapid diagnostic test

IQR- Interquartile range

aOR- Adjusted Odds Ratio

LLIN- Long-lasting insecticides treated nets

CI - Confidence interval

NMCP - National Malaria Control Programme

GEE- Generalized Estimating Equations

CHCWs- Community-based Health Care Workers

HFs- Health facilities

Declarations

Ethics approval and consent to participate

The Medical Research Coordination Committee of the National Institute of Medical Research granted the permit to conduct the ethics approval for the study (NIMR/HQ/R.8a/Vol.IX/2005). Institution ethical approval was also obtained from the Ifakara Health Institute Institutional Review Board (IHI/IRB/No: 18-2015) and the Chinese Centre for Disease Control (201505). Informed consent was obtained directly from the head of the households and for the participants >18 years, consent/assent was obtained from parents or guardians for children who are >13 but <18 years and live with a parent or guardian. The consent forms were prepared in English and translated into Kiswahili (the local language). For adults who were not able to read the form, the informed consent form was read out by the local CHCWs in the presence of a community witness (Balozi) and the participant was asked to mark a thumb impression on the form, and the witness signed it.

Consent for publication

Not applicable

Availability of data and materials

All relevant data can be made available upon receipt of official requests while ensuring participant and community data privacy and confidentiality.

Competing interests

The authors declare that they have no competing interests.

Funding

Data collection for this study was financially supported by the UK DFID through the China-UK Global Health Support Programme [Award number GHSP-CS-OP4-D02]. The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the manuscript. DQW, PPC, XNZ, SA, HM, NX, and YPM had access to all the data in the study and had final responsibility for the decision on submission of the paper.

Authors' contributions

XNZ, NX, and SA conceived and designed the project. DQW and PPC designed and implemented the project. YPM, DQW, and PPC drafted the manuscript. SA, GT, ET, MT, XNZ provided further revisions. YPM, KR, HMM, EH, and SA performed the statistical analysis of the study. YPM, PPC, DQW, TG, MGM, MT, SA, XNZ, and all the other authors implemented the study and reviewed the manuscript. All authors read and approved the final manuscript.

Acknowledgments

The authors would like to thank the Rufiji District Authority, the study area communities, and CHCWs that participated in this project. We acknowledge the WHO Country Office in Tanzania, Ministry of Health, Community Development, Gender, Elders and Children -NMCP, National Institute of Medical Research (NIMR), UK-aid (DFID) Country office in Tanzania, and the Swiss Tropical Institute for their dynamic support and cooperation during the project. We also like to thank, Mwaka Kakolwa, Irene Masanja, Ramadhan Abdul, and Festo Charles for their valuable assistance during study data tools development, data cleaning, and statistical analysis plan. We sincerely appreciate the Chinese field team from National Institute of Parasitic Diseases Chinese Center for Disease Control and Prevention, Anhui Provincial Center for Disease Control and Prevention, Shandong Provincial Institute of Parasitic Diseases, Yunnan Provincial Institute of Parasitic Diseases, Sichuan Provincial Center for Disease Control and Prevention and Chongqing Municipal Center for Disease Control and Prevention, who provided invaluable technical support in the field.

Consent for publication

All authors have given their consent for this publication.

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Figures

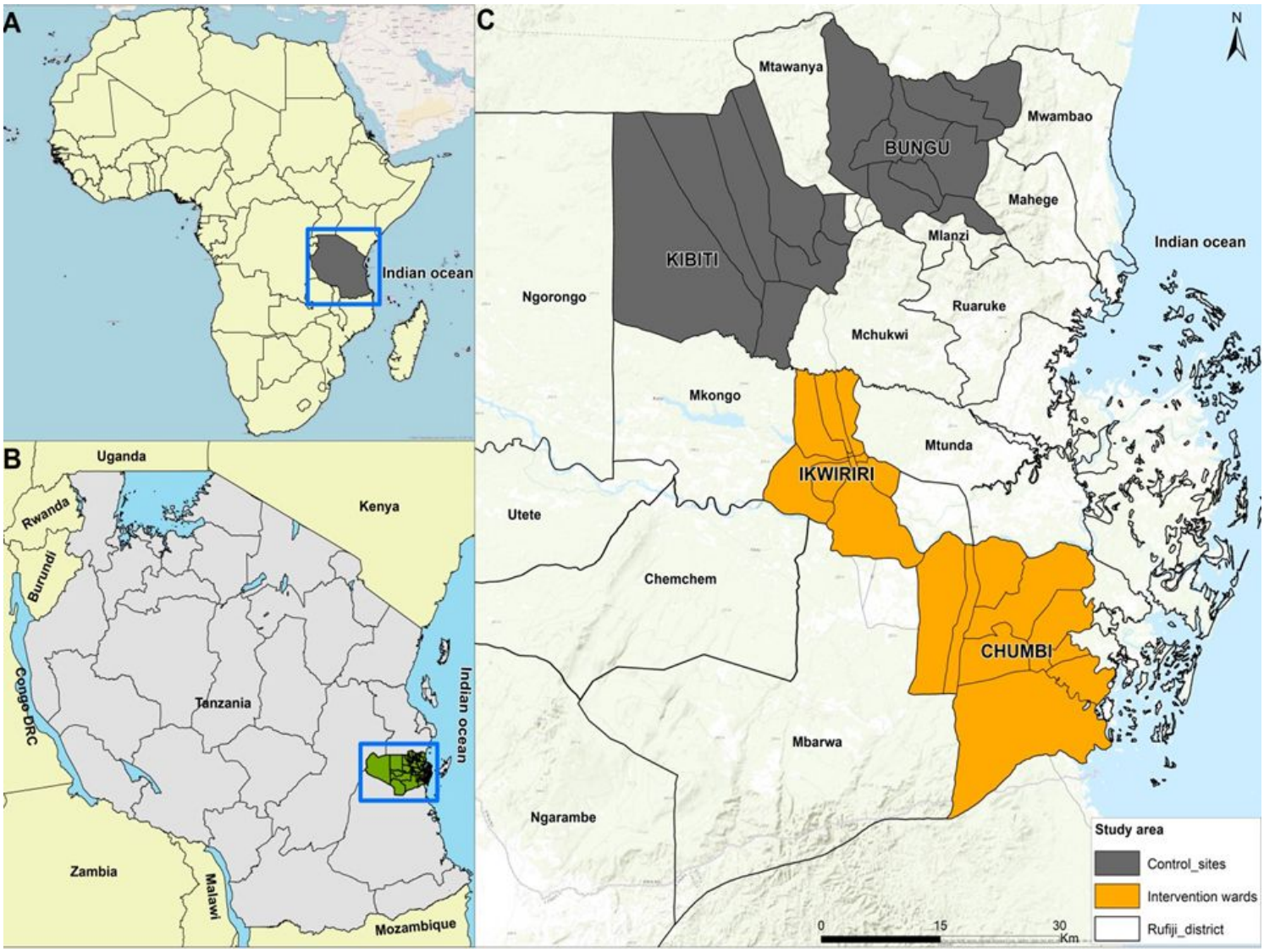

Figure 1

: Location of the study area in, Rufiji district, Tanzania. [A] Overview map of Africa showing Tanzania location, [B] overview location of Rufiji District in Tanzania, [C] overview map of Rufiji district indicating

the intervention(Ikwiriri and Chumbi) and control wards (Bungu and Kibiti). Base Map was obtained from OpenStreetMap through the ArcGIS plugin.

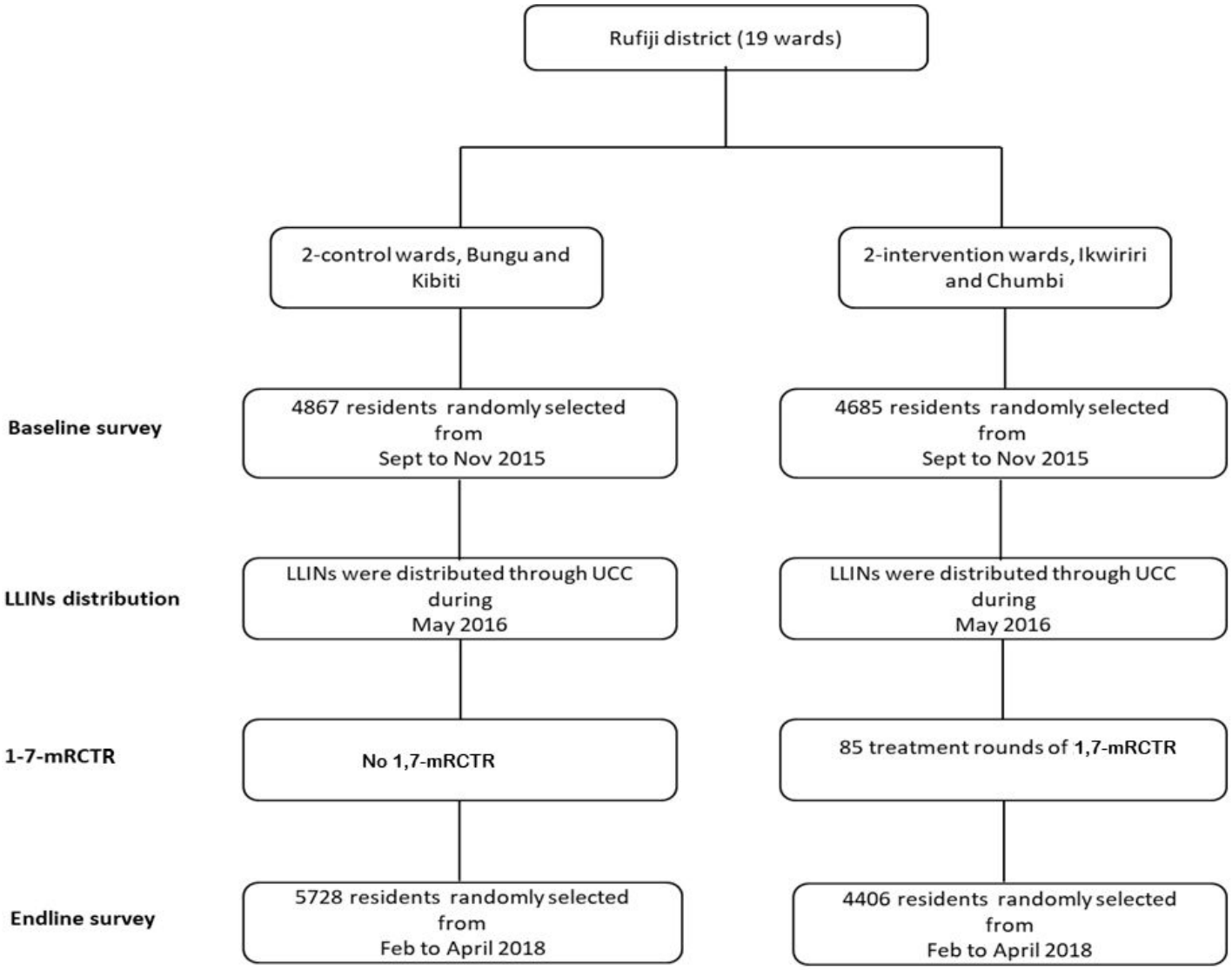

Figure 2

Schematic diagram of the study design and implementation profile of 1,7-mRCTR approach

Supplementary Files

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