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Reduction in symptomatic malaria prevalence through proactive community treatment in rural Senegal

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Abstract

OBJECTIVES We piloted a community-based proactive malaria case detection model in rural Senegal to evaluate whether this model can increase testing and treatment and reduce prevalence of symptomatic malaria in target communities.

METHODS Home care providers conducted weekly sweeps of every household in their village throughout the transmission season to identify patients with symptoms of malaria, perform rapid diagnostic tests (RDT) on symptomatic patients and provide treatment for positive cases. The model was implemented in 15 villages from July to November 2013, the high transmission season. Fifteen comparison villages were chosen from those implementing Senegal's original, passive model of community case management of malaria. Three sweeps were conducted in the comparison villages to compare prevalence of symptomatic malaria using difference in differences analysis.

RESULTS At baseline, prevalence of symptomatic malaria confirmed by RDT for all symptomatic individuals found during sweeps was similar in both sets of villages ($P = 0.79$). At end line, prevalence was 16 times higher in the comparison villages than in the intervention villages ($P = 0.003$). Adjusting for potential confounders, the intervention was associated with a 30-fold reduction in odds of symptomatic malaria in the intervention villages (AOR = 0.033; 95% CI: 0.017, 0.065). Treatment seeking also increased in the intervention villages, with 57% of consultations by home care providers conducted between sweeps through routine community case management.

CONCLUSIONS This pilot study suggests that community-based proactive case detection reduces symptomatic malaria prevalence, likely through more timely case management and improved care seeking behaviour. A randomised controlled trial is needed to further evaluate the impact of this model.

keywords malaria, Senegal, community health workers, early diagnosis, mass screening, pilot projects

Introduction

Correct case management, which includes diagnostic confirmation of suspected cases and appropriate treatment within 24 h of symptom onset, is an essential piece of any strategy for malaria control or elimination [1–3], both for prevention of severe malaria and reduction of the parasite reservoir in a community [4, 5]. It is estimated that, if suspected cases of malaria are identified early, confirmed by rapid diagnostic test (RDT) and treated correctly with artemisinin-based combination therapies (ACTs), malaria cases in a community can be reduced by 34% and malaria-related hospitalisations by 39% [1]. However, many sub-Saharan African countries will not achieve the global malaria action plan (GMAP) targets for universal access to appropriate case management by 2015 [2, 6–8].

Determinants of access to care and of care seeking behaviour include geographic proximity, ease of accessing or attending a facility, ease of receiving treatment [9], affordability, acceptability and availability [6]. These factors can act as barriers to treatment seeking or lead to

incorrect treatment [10]. The poorest and most vulnerable populations are most affected by these barriers, and poverty has been found to be the greatest determinant in health seeking behaviour [6,11]. Fewer than 20% of children with malaria in endemic zones are treated within the formal health system [12], and most children who die from malaria do so at home without having received proper treatment [13].

Community case management of malaria (CCM) aims to address access barriers and bring treatment closer to home by training home care providers (HCPs) for malaria at the village level. This strategy has been widely implemented in sub-Saharan Africa and has been found to be feasible, accessible and effective [11, 14–17]. Senegal has long been heralded for its work in integrated CCM, with CHWs operating community-based health facilities since the 1950's [18]. In 2009, Senegal expanded coverage of community case management of malaria to villages farther than 5 km from a health structure through a home-based management programme known by its French acronym PECADOM (*prise en charge à domicile)*. The new programme trained HCPs whose purview was explicitly the diagnosis and treatment of uncomplicated malaria. In regions where PECADOM was implemented, malaria-related deaths declined by 62.5%. In a comparable, non-PECADOM region, deaths dropped by only 15.4% during the same time period, likely due to other concurrent malaria control interventions [17].

In Kedougou, one of the initial PECADOM regions, Saraya Health District (SHD) trained 8 HCPs in 2009, and their number rose to 45 by 2013. The programme was successful in increasing access to care, with a fivefold increase in individuals with a trained HCP in their village from 2008 to 2011 [19]. Challenges accompanied this success; evaluators observed programmatic barriers such as seasonal variation in HCP activity and RDT and ACT stock-outs. PECADOM's passive model of malaria case detection (wherein the onus remained on the patient to seek appropriate treatment) led to underutilisation of HCPs. Communities continued to seek care from traditional healers and waited to seek appropriate treatment until severe disease required transport to the formal health structure [20].

The Institute of Medicine stresses that measurement of access must include well-timed utilisation [4]. GMAP targets for universal coverage of effective interventions translate to 80% utilisation [8]. The gap between availability and timely utilisation of HCPs can result from community perceptions of drug availability, cost, illness severity and healthcare quality [6]. Even in settings with high awareness of the importance of treating malaria within the formal system, these perceptions are strong barriers to treatment seeking [6, 9, 15].

To overcome behavioural barriers to care seeking, a proactive case detection component was added to PECADOM in a rural village in SHD in 2012 [21]. Under this project, designated PECADOM Plus, HCPs conducted weekly proactive sweeps of the village to identify individuals of any age with symptoms of malaria, test them with RDTs and treat positive, uncomplicated cases with ACTs. The intervention village showed both an increase in cases treated and a decrease in malaria prevalence compared with two similar villages. Due to the success of this model of proactive community treatment (ProACT), SHD and the US Peace Corps, with support from the NMCP, conducted a larger pilot of the PECADOM Plus programme to evaluate the feasibility and effectiveness of the model.

Methods

Study site

Saraya Health District, located in the extreme south-east of Senegal in the region of Kedougou, is a very remote and rural district. The 6800 km^2 district borders Mali and Guinea. In a 2013 census conducted by SHD for the purposes of an LLIN distribution, the population was estimated at 52 590 full-time residents, not including the influx of artisanal small-scale gold miners in the area. The population density is fewer than 9 people per km^2, and 70% of this population lives more than 5 km from a health post or a health centre [19].

Kedougou region is the poorest in Senegal, with 61% of households in the lowest wealth quintile. Child mortality is estimated at 154 deaths per 1000 live births. Kedougou, including SHD, has the highest prevalence of *Plasmodium falciparum* among children under 5 in Senegal (13.5% compared to the national average of 3%) [22]. A study of malaria transmission in one village in the region found the entomological inoculation rate (EIR) to be up to 4.6 infective bites per person per night during the high transmission season [23], whereas the average EIR for Senegal is 25.3 infective bites per year [24].

Saraya Health District also implemented two other malaria control interventions during the 2013 PECADOM Plus study period in all villages in the district: universal coverage distribution of long-lasting insecticidal nets (LLINs) (July 15–25) and one round of seasonal malaria chemoprevention (SMC) (November 1–4).

Study design

This was a quasi-experimental study design with the goal of evaluating the feasibility and effectiveness of the

ProACT model in reducing the prevalence of symptomatic malaria. Within the catchment areas of four of the district's 11 health facilities, the 15 villages home to trained HCPs were selected to receive the intervention. In the intervention villages, the HCP performed weekly ProACT sweeps, going door to door to every household in the village, checking for individuals of all ages with symptoms of malaria, in addition to the routine, passive CCM services where individuals could initiate care by seeking out the HCP. Prevalence of symptomatic malaria was estimated through the testing of every symptomatic individual in the village with RDT.

Intervention villages had a total population of 4217. From SHD's other health facility catchment areas, fifteen additional villages with an HCP and similar populations and rainfall patterns served as comparison villages that continued to use only the passive CCM model. The total population of these villages was enumerated at 4747. The prevalence of symptomatic malaria was estimated in the comparison villages (employing the same proactive sweep methodology as in the intervention villages with an HCP shadowed by a Peace Corps Volunteer to ensure data quality) at the beginning, middle and end of the study period.

Pilot implementation

All HCPs received training from SHD on the national standard of care for diagnosis and management of malaria in the PECADOM programme:

- Temperature taken of all febrile individuals.
- Rapid diagnostic test performed for each suspected case (determined by fever, history of fever in the preceding 48 h, or other symptoms such as headache or vomiting).
- Uncomplicated malaria diagnosed and ACTs given to individuals with a positive RDT and fever below 39.5°.
- Individuals with a negative RDT, fever higher than 39.5 degrees and/or other danger signs immediately referred to the nearest health facility, along with pregnant women and children under two months of age, who, according to national policy, are outside the purview of HCPs.
- Home care provider facilitates referrals – communicating with the health facility and where possible assisting with the referee with transport through advocating with village leadership for means of transportation or even accompanying them in the case of a severely ill patient.
- Home care providers follows up with diagnosed patients at 48 h to ensure treatment compliance [25].

The intervention HCPs received a separate, day-long training on the proactive component of the ProACT model. HCPs subsequently held community trainings to train one woman from each compound about the symptoms of malaria and to raise awareness about the forthcoming weekly sweeps. Each health facility's head nurse explained the model to community leaders and obtained their consent before the pilot's launch.

Intervention HCPs conducted weekly sweeps from July 8 through November 28. During these weekly sweeps, typically conducted on Mondays (the day of the week when gold mines were closed and a common day of rest from the fields), the HCP would visit all households in the village in a door-to-door approach, verbally inquiring if there was anyone in the household who was febrile or showed other symptoms of malaria. A woman from each household who had received training prior to the programme often acted as the first-level screener and facilitated the identification of symptomatic individuals who were then tested and treated in accordance with the national standard of care as described above.

Supervision was carried out by community supervisors, health post nurses and the executive team from the health district. Peace Corps Volunteers supported this supervision structure at each level, providing additional supervision for HCPs with lower literacy levels to ensure quality and completeness of data.

Data collection

During each sweep, HCPs recorded the age, sex, symptoms of the patient, RDT outcome, whether treated or referred, and either treatment dosage given or the reason for referral. These data were collected using paper-based tools that were almost identical to the registers utilised in the original PECADOM model in order to minimise data collection errors. The tools differed only in the inclusion of questions about other malaria control interventions. Data from the HCPs' work between sweeps through passive CCM were also collected. For health facility data, the date, age, severity and village of origin of each case of malaria were extracted from the consultation registers from intervention and comparison zone health facilities for July through November for both 2012 and 2013.

Data analysis

Data were entered into MS Excel and analysed using MS Excel and SAS 9.3. Unadjusted and adjusted analyses were performed based on cluster-level summaries of the endpoints of interest, including HCP productivity, prevalence of symptomatic malaria, care seeking for

malaria at health facilities. A difference in differences (DiD) approach was used to determine an overall measure of intervention effect [26, 27], utilising logistic regression modelling and adjusting for the effect of the clustered intervention design.

Ethical considerations

Ethical approval was sought and obtained from the Senegalese Ministry of Health's National Committee on Ethics for Health Research. In accordance with national policy, both RDTs and ACTs were provided free of charge. Verbal consent was obtained prior to testing, and diagnosis and treatment offered to symptomatic persons were given according to the national standard of care.

Results

Data were collected for 14 of the 15 intervention villages (data from the remaining village were excluded due to poor data quality; as a result, total intervention population for analysis purposes was 3762) and 15 comparison villages for the 21-week study period. Table 1 displays the attributes of the intervention and comparison villages and their coverage levels for other malaria control interventions. Population, net coverage and SMC coverage did not differ significantly between intervention and comparison villages when controlling for the effects of clustering of villages by health facility.

Table 1 Characteristics of study villages, stratified by intervention and comparison groups

Attribute	Intervention villages (n = 14) Mean	Comparison villages (n = 15) Mean	P-value
Population	268.7	316.4	0.53
Pre-distribution net coverage*	26.7%	20.2%	0.12
Post-distribution net coverage†	100%	98.4%	0.18
SMC coverage‡	90.3%	97.4%	0.42

SMC, seasonal malaria chemoprevention; SHD, Saraya Health District.
*Net coverage (defined by nets/sleeping space) measured by Saraya Health District (SHD) through census prior to July 2013 universal distribution.
†Net coverage (defined by nets/sleeping space) measured by SHD post-July 2013 universal distribution.
‡SMC coverage of children under 10 years old measured by SHD after November 2013 SMC campaign.

Operational results

In terms of process indicators, the group of intervention HCPs completed 89% of the total sweeps for the 21-week study period. Major reasons for non-completion of sweeps were gold mining, illness and, in one village, ACT stock-out. The HCPs performed 1036 RDTs through proactive case detection, 647 of which were positive. HCPs correctly followed national policy for testing and treatment; of all negative RDTs, only two patients were incorrectly given ACTs. In addition to referrals for negative RDTs, 23 severe cases were referred. Four HCPs also demonstrated non-adherence to national policy on several occasions by treating cases with a temperature higher than 39.5 with ACT in the household as well as referring the individual for treatment at a health facility.

Weekly totals of RDTs performed during sweeps by intervention HCPs and numbers of positive RDTs are demonstrated in Figure 1. Timing of other malaria control interventions is also included in the figure to demonstrate the whole picture of malaria control activities in the district.

In the 7 intervention villages with an active HCP prior to 2013, we compared the work of these same providers operating under each of the programme models – passive CCM only and passive CCM in addition to ProACT. RDTs performed during the high transmission period increased by 95% between 2012 and 2013 (P = 0.03), and home treatment with ACTs or referral for positive RDTs increased by 69% (P < 0.001). The effect of ProACT on HCP performance appears even greater when compared to the two comparison villages with available data on passive CCM in 2012 and 2013 (Table 2). Adjusting for the effects of covariates, ProACT was associated with a 153% increase in RDT performance (P < 0.004) and a 128% increase in home treatment with ACTs (or referral if necessary) for positive RDTs (P = 0.01).

Prevalence of symptomatic malaria

Proactive sweeps were conducted in the comparison villages during the weeks of July 8th, September 23rd and November 25th to obtain baseline, midline and end line measurements of symptomatic prevalence. Figure 2 compares the mean prevalence of symptomatic malaria at each point, as measured by positive RDT of all community members presenting with symptoms. During baseline sweeps, the mean prevalence was 1.9% in the intervention villages and 1.6% in the comparison villages (P = 0.79). During the midline sweeps, a mean prevalence of 1.2% was found in the intervention villages,

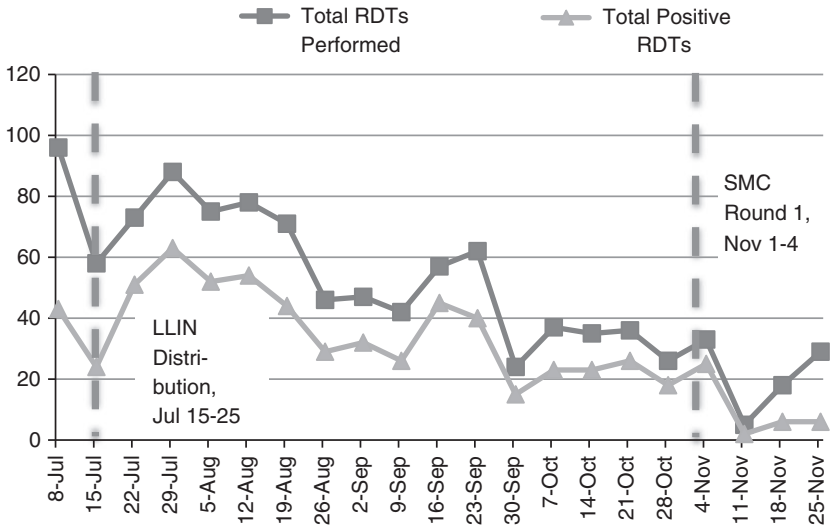

Figure 1 Total rapid diagnostic tests (RDTs) performed and positive RDTs by week in the intervention villages (n = 14).

Table 2 Percent increase in rapid diagnostic tests (RDTs) performed and positive RDT treated or referred for by HCPs in the intervention villages (n = 7) relative to comparison villages (n = 2)

	Unadjusted effect (%)	95% CI	*P*-value	Adjusted effect (%)*	95% CI	*P*-value
RDTs performed	1.45	0.75–2.16	0.003	1.53	0.77–2.29	0.003
Positive RDT†	1.16	0.47–1.86	0.007	1.29	0.46–2.11	0.010

*Adjusting for population size, net coverage, annual rainfall, and clustering by health zone.
†ACT treatment if uncomplicated or referral if severe.

compared to 3.0% in the comparison villages (P = 0.007). At end line, mean prevalence dropped to 0.2% in the intervention villages and to 3.35% for comparison villages (P = 0.003).

Difference in differences analysis was used to estimate the overall effect of the intervention on symptomatic malaria prevalence in the study villages by end line, accounting for prevalence measures at baseline and midline (Table 3). Before adjusting for the effects of other covariates, the intervention was associated with a 16.98-fold reduction in the odds of symptomatic malaria in the intervention villages relative to comparison villages (OR = 0.06; 95% CI: 0.04, 0.08). Adjusting for other covariates, the adjusted odds of symptomatic malaria were 30 times lower in the intervention villages relative to comparison villages (AOR = 0.03; 95% CI: 0.02, 0.07).

Treatment seeking behaviour

Of the 2419 total patients tested with RDTs by HCPs in the intervention villages during the project period, 1383 (56%) were identified through passive CCM between weekly sweeps. Likewise, 60% of the 1665 cases with positive RDT treated by HCPs were detected passively, indicating that the population did not wait for the sweeps to seek care. These numbers are shown in Figure 3. In the intervention villages, 37% of the total population sought care from an HCP through passive CCM and was tested with RDT (compared to 10% in the comparison villages).

Difference in differences analysis also shows the estimated effect of the intervention on the odds of being consulted at local health posts for malaria cases for individuals from intervention and comparison villages from 2012 to 2013. Table 4 shows the associated unadjusted and adjusted odds ratios, which demonstrate that the intervention was not associated with any significant change in the odds of treatment seeking through health post consultation.

Discussion

The results of this pilot study demonstrate that proactive case detection of malaria through weekly sweeps by home care providers may contribute to a significant decrease in the prevalence of malaria and increased capacity of the providers. ProACT was associated with a

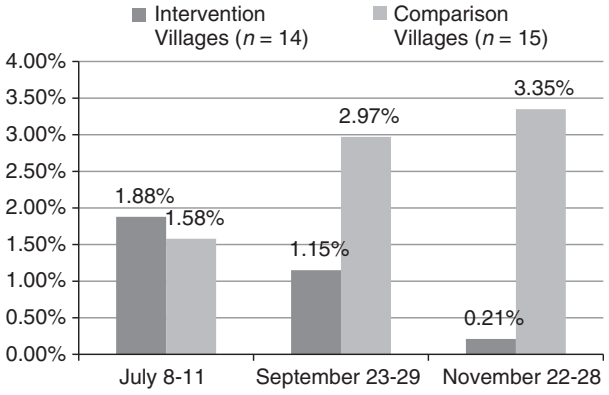

Figure 2 Comparative mean prevalence of symptomatic malaria (all ages).

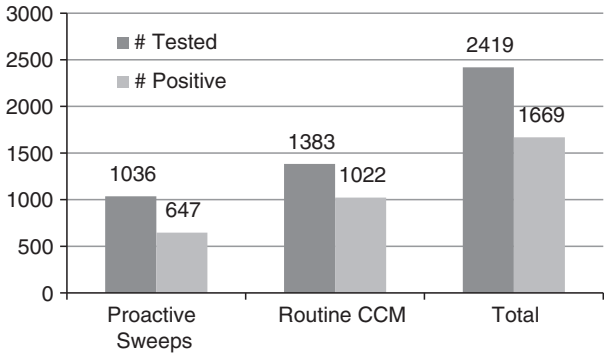

Figure 3 Rapid diagnostic tests (RDTs) performed and cases detected (all ages) through routine and proactive case detection methods in the intervention villages (n = 14), July—November.

Table 3 Difference in differences (DiD) estimates of effect of intervention on prevalence of symptomatic malaria

	Effect estimate	95% CI	*P*-value
Unadjusted odds ratio (OR)	0.06	(0.04, 0.08)	<0.0001†
Adjusted odds ratio (AOR)*	0.03	(0.02, 0.07)	<0.0001†

*Controlling for population size, SMC coverage, pre- and post-distribution net coverage.
†Significant at $\alpha = 0.05$.

Table 4 Difference in differences (DiD): unadjusted estimates of effect of intervention on odds of being treated for malaria at local health posts for individuals from intervention villages compared to comparison villages, 2012–2013

	Effect estimate	95% CI	*P*-value
Unadjusted odds ratio (OR)			
Total cases	0.98	(0.72, 1.35)	0.92
Uncomplicated Cases	0.83	(0.55, 1.26)	0.39
Severe cases	1.51	(0.76, 3.01)	0.24
Adjusted odds ratio (AOR)*			
Total cases	1.09	(0.61, 1.94)	0.78
Uncomplicated cases	0.96	(0.43, 2.14)	0.92
Severe cases	1.22	(0.44, 3.37)	0.70

*Controlling for population size, SMC coverage, pre- and post-distribution net coverage.

30-fold reduction in overall odds of symptomatic malaria, and, while this study did not directly measure asymptomatic prevalence, increased testing and treatment in the setting of the scale-up of other interventions has been shown elsewhere to contribute to a decline in transmission reservoir [5]. This suggests that the ProACT model may be an important strategy in reaching the GMAP targets of universal access to effective case management of malaria and achieving the additional 10-fold reduction in cases that is needed to meet the new Roll Back Malaria Objectives [3].

The availability, acceptability and affordability aspects of access to care and care seeking behaviour are each addressed in this model. Care is available to rural villages through the standard CCM model, but the weekly sweeps reinforce understanding of this availability and move it towards acceptability: when cases of malaria are identified and treated early, the efficacy of the medication and the competence of the provider are proven [16]. Local perceptions of the high cost of treatment [20] are disproved when the HCP distributes ACT free of charge. Each of these elements then affects the iterative treatment seeking decision process that is often based on the perceived effectiveness of a treatment option [10]. The finding that the majority of cases treated by intervention HCPs were identified between sweeps through passive CCM was highly encouraging and has been documented elsewhere in studies of active case detection [28, 29]. The observed increase in treatment seeking behaviour likely also had an effect on malaria prevalence.

Cost has been cited as a barrier to the implementation of active case detection programmes [30]. However, just as passive CCM has been shown to be more cost-effective than facility based treatment [31], community based models of active case detection can address this barrier. Whether or not to pay CHWs has been a source of major debate in the international community [12]. The ProACT experience demonstrates the value of paying HCPs to perform a service that takes time away from other possible income generating activities. In the case of SHD, a recent gold rush has tended to pull HCPs away from their vil-

lages. We found that, in the intervention villages, only 3% of sweeps were missed due to travel associated with gold mining. However, in the comparison villages, 6 of the 15 volunteer HCPs were not in their villages for the end line comparison sweeps due to extended travel to gold mining sites, and other CHWs had to be brought to the villages to complete the comparison sweeps and estimate prevalence. This suggests that a paid weekly activity may have kept intervention HCPs in their villages. The small financial motivation given to HCPs made up only one third of the intervention costs and was considered essential to the success of the programme.

This pilot study had several limitations. First, the aforementioned gold rush could be a potential confounder [32] due to varying levels of HCP mining activity and transience of village residents. Gold mining was not controlled for as a confounding factor in the analysis because data on gold mining (HCP and general population level of mining activity, mining location and proximity of villages to mines) were not systematically collected for the purposes of this study. However, HCPs and residents of both intervention and comparison villages were conducting mining activities, and the biggest mine, where nearly all of the HCPs who mined were doing so, was located in the intervention zone, which may have biased the effect towards the null.

Additionally, due to the leadership role of Peace Corps Volunteers in coordination and supervision, the intervention villages were selected as a convenience sample on the basis of their proximity to Peace Corps Volunteer sites. As the sites were not randomised, causal impact of the project on malaria incidence and prevalence cannot be proven. A third limitation was the absence (due to funding limitations) of procedures to directly measure severe malaria incidence or parasite prevalence or to assess deaths from malaria at the village level in order to measure changes in malaria-specific mortality. One health facility register was missing from an intervention village facility, which may explain the lack of association of the intervention with cases of malaria seen at the facility level.

With the data collected from an additional question on sweep data collection tools regarding whether eligible children had received SMC, we estimated that the protective efficacy of SMC was between 64% (assuming 80% coverage) and 84% (assuming 90% coverage) in both the intervention and comparison villages. During the last sweeps in the intervention villages and the end line comparison sweep, both sets of HCPs asked all consulted patients whether they had slept under LLIN the night before: 96% in the intervention villages (n = 28) and 85% in the comparison villages (n = 241) responded in the affirmative. Taking into consideration bias from social pressure to respond in the affirmative (especially among respondents who are sick), these data indicate relatively high coverage in both sets of villages. This supports the contention that the pilot study took place in a context of high LLIN utilisation, which indicates that the ProACT model can substantially contribute to the protection offered by LLINs. It appears that the combination of these other interventions and ProACT greatly diminished the burden of malaria in the intervention villages relative to the comparison villages, and the data suggest that the effects of SMC and ProACT are independent.

It has been suggested that treatment as prevention is most effective in areas of lower transmission, and research on high transmission areas has been named a high priority in the research agenda for malaria elimination [33]. The findings of this pilot study suggest that further evaluation is needed in using the ProACT model for treatment as prevention in higher transmission areas and to determine the fit of sustained, community-based proactive symptomatic case detection in all epidemiologic settings and among other treatment as prevention strategies. It has been determined elsewhere that the long-term duration of mass drug administration impact is predicted to be low in high transmission zones, particularly in areas with transient populations, such as the case in Saraya, due to gold mining [34]. Low sensitivity of RDT on asymptomatic carriers [35], difficulty achieving the necessary population coverage, cost and logistical difficulty also discourage mass screen and treat (MSAT) as a sustainable malaria control strategy [1, 36], and the model has not been shown to have a significant impact on incidence of symptomatic malaria [37]. A recent study of a community-based MSAT model found that monthly active visits were insufficient in reducing the reservoir for transmission due in part to low levels of community consent to be tested on a monthly basis [15]. Focusing home visits on symptomatic malaria may prove to be an effective alternative [30]. ProACT may be an effective service delivery model that strengthens health systems by making better use of professional resources, as called for in the GMAP [8].

In 2014, the Senegalese NMCP scaled up the use of ProACT throughout the region of Kedougou, integrating screening and treatment for diarrhoea and respiratory infections into the sweep methodology. Results from that scale-up will further inform the findings of this pilot study on the feasibility and effectiveness of community-based proactive case detection.

Conclusion

It has been argued that malaria will persist as a major cause of morbidity and mortality unless action is directed

towards lifting the barriers to access to care among the poor and vulnerable in sub-Saharan Africa [6]. This pilot study demonstrates that weekly community-based proactive case detection could increase access to and utilisation of appropriate case management, playing a role in moving towards international targets. ProACT is an area of intervention worthy of further exploration, and we recommend continued scale-up, along with a randomised controlled trial in multiple epidemiological zones designed to evaluate impact on severe malaria and parasite prevalence in addition to prevalence of symptomatic, uncomplicated malaria.

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