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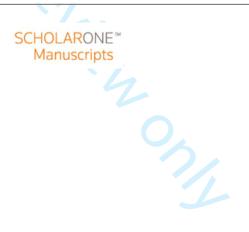
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Proactive and reactive case detection to optimise integrated community case management of malaria in a high transmission setting of Cameroon

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Proactive and reactive case detection to optimise integrated community case management of malaria in a high transmission setting of Cameroon

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CLICZ

Abstract

Objective: Integrated community case management (iCCM) of childhood illness is a powerful intervention to reduce mortality. Yet, less than 20% of children with fever in sub-Saharan Africa have access to malaria testing. We sought to explore how incorporating proactive and reactive case detection of malaria into iCCM could help accelerate coverage.

Design: A community-led project to proactively screen febrile children under five years for malaria using rapid diagnostic testing and then using index cases to reactively detect more cases

Setting: Four primary schools, 4 health facilities and 13 neighbourhoods of the rural community of Bare-Bakem in Cameroon

Participants: Children and adults with fever

Intervention: Proactive and reactive case detection of malaria between 12 weeks between April and June 2018

Primary and secondary outcome measures: The proportion of index and secondary malaria cases detected during iCCM compared to the intervention

Results: We screened a total of 501 febrile cases of whom *Plasmodium* infection was confirmed in 425 (84.8%) cases including 176 (83.4%) among index cases and 249 (85.9%) among secondary cases. Of the 425 confirmed cases, 102 (24.0%) were index cases identified in the community during routine iCCM activity; 38 (8.9%) were index cases identified proactively in schools; 36 (8.5%) were index cases located in health facilities; and 249 (58.6%) were additional cases detected in the homes of index cases by RACD - showing the value of RACD over iCCM alone. Overall, by incorporating an active case detection approach, iCCM must have been improved by 67.5% to manage malaria cases in the community.

Conclusion: Most symptomatic cases of malaria remain undetected in the community despite the introduction of community case management of malaria but these undiagnosed cases can be mopped-up by adopting a proactive and reactive case detection approach. This approach should be targeted to schools, older children and large households.

Article Summary

Strengths and Limitations of this study

- The first study to show the clinical relevance of a reactive case detection strategy in a high malaria transmission area
- The study used existing community resources but in a more target manner to maximise access to malaria treatment in a poor and rural community

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• A small-scale study with no control arm carried out during a relatively short period and during the high transmission season thus inclined towards over-estimating the value of the intervention

Introduction

In Cameroon, malaria-related morbidity has reduced from 40.6% in 2008 to 23.6% in 2016 while malaria mortality has reduced from 17.6% in 2000 to 12.4% in 2016[1-3]. Despite this remarkable effort, malaria remains a major public health problem in Cameroon where the entire population of more than 25 million inhabitants is at risk, with 71% living in high transmission areas [4]. In 2016, approximately 1.7 million malaria cases and 2637 deaths from malaria were recorded in health facilities in Cameroon. Children under five years of age were the most affected group in whom malaria was responsible for 41% of all case morbidity, 55% of hospital admissions and 69.7% of all malaria-attributed deaths in 2015[2]. To reduce childhood mortality, Cameroon and her development partners began implementing integrated community case management (iCCM) of pneumonia, diarrhoea, and malaria in 2009 to target communities with difficult access to health services. Community case management (CCM) of malaria can reduce overall and malaria-specific under-five mortality by 40% and 60%, respectively, and severe malaria morbidity by 53%[5, 6]. Yet in 2011, less than 20% of children with fever in sub-Saharan Africa received a finger/heel stick for malaria testing[7]. In some localities of Cameroon, iCCM strategy has been reported to have increased treatment rate for malaria, increased care seeking for fever and reduced burden on healthcare facilities[8, 9]. However, data from a community needs assessment conducted in 2016 in the rural community of Bare-Bakem in the Littoral Region of Cameroon indicated that malaria represented up to 80% of all-cause morbidity across health centres and that iCCM has been facing significant challenges including: passiveness in operation; low uptake, underutilisation and attrition of trained community health workers (CHW); prolonged and frequent stockouts of commodities for malaria diagnosis and treatment; inadequate supervision and motivation. School children though typically constituting the group with the highest prevalence of Plasmodium infection, have been virtually left out of this intervention despite receiving increasing attention recently [10-12]. In response to these challenges that threaten to reverse the initial iCCM gains, Peace Corps Cameroon has been supporting rural communities in Cameroon to effectively fight malaria. In 2018, the Peace Corps community of Bare-Bakem introduced a proactive and reactive case detection approach into the existing iCCM system with the objective to reduce malaria burden by expanding access to prompt malaria case

management in the community. Integrating active (proactive and/or reactive) case detection strategy with iCCM has not yet been documented in high transmission settings. We report how in this community-led project, CHW proactively searched for cases of malaria in children under five in schools, health facilities and households; and then using index cases, they reactively detected and treated even more cases in the community by visiting the households of the sick children with confirmed malaria.

Methods

Intervention site and priority setting

The intervention was carried out in the rural town of Baré, the headquarters of Baré -Bakem municipality with a population of about 20000 inhabitants occupying a surface area of about 200km². Bare is situated at approximately 10 km from Nkongsamba (the divisional capital) and 120 km from the coastal city of Douala (the regional capital). It has 13 neighbourhoods: Bareko, Ebouth, Axe-Lourde, A, A bis, B, B bis, C, D, E, E bis, F and F bis. The locality's low elevation and its equatorial warm and wet climate are conducive for the multiplication of mosquitoes and eventually malaria endemicity. The town is host to a Peace Corps Volunteer (PCV) for the period between 2016 and 2018 with the mission to support efforts to fight infant and maternal mortality, malnutrition, malaria and HIV/AIDS. On average, across all the four health facilities in Baré, malaria made up approximately 40% of all sicknesses reported in 2016. Cases of malaria can even represent up to 80% of all sicknesses during the wet season. A Community Needs Assessment (CNA) carried out in December 2016 and January 2017 prior to the intervention indicated that malaria was the number one health priority for the community. Of the 250 people that were interviewed, 84% claimed that malaria was Baré's most important health problem. Malaria has a particularly devastating effect on children under the age of five, over 50% of consultations for children under five vears old are confirmed cases of malaria. Despite the recognition that malaria is the community's top health priority – only 34% of participants could correctly explain the mode of transmission of malaria. Similarly, there is very limited access to health facilities and inadequate health-seeking behaviour for malaria treatment. About 80% of the population indicated that they initially seek care from traditional healers or road-side drug vendors. This is why a focus on malaria prevention and education is important but prompt and expanded access to malaria treatment so critical in Baré.

Intervention description and evaluation

During 8 weeks of the high transmission period between April and June 2018, Baré's six CHW locally known in French as "*Agent de Santé Communautaire* (ASC)" conducted an active malaria case detection (ACD) involving both a proactive case detection (PACD) phase and a reactive case detection (RACD) phase.

Before launching, the project trained 25 primary and nursery school teachers on malaria detection and the promotion of prevention & care seeking behaviour. Each ASC was assigned to a school and a collaborative system among teachers and ASCs working together to detect sick children was developed. Consent forms were distributed to the teachers to pass along to parents of pupils for their approval to test their children. The four health centres were also invited to the training in order to build working relations with ASCs and all the health centres in Baré. The ASCs had been trained repeatedly over the past years by the National Malaria Control Programme (NMCP) on community management of malaria, iCCM but they were briefed alongside two supervisors on the specificities of this project. One supervisor was in charge of correct data collection, while the other inspected schools and visited households to ensure effectiveness of field work.

PACD was undertaken in 12 primary & nursery schools, 4 health centres, and 13 community neighbourhoods on a weekly basis. Each week on a Thursday, ASCs visited assigned schools and health centres for a febrile screening. Upon arriving at their schools, the trained teachers will indicate the pupils under five who recently had a fever (axillary temperature of 38°C or more). Health workers similarly helped to identify febrile children admitted in health facilities. Children with fever were identified as index cases, tested freely for Plasmodium infection using rapid diagnostic tests (RDT) approved and supplied by the NMCP. Those tested positive for malaria were further classified as either uncomplicated or severe malaria. Uncomplicated malaria cases were immediately treated with amodiaquine + artesunate, the first-line artemisinin-based combination therapy (ACT) recommended and supplied by the NMCP. Severe cases and RDT-negative cases were referred to health facilities for further investigation and management as per the NCMP guidelines. If an index case was absent from school the day the ASC arrived, the teacher would tell the ASC where the child lives. The ASC would visit the household and proceed as above. In the community however, ASCs continued to identify febrile children as per the conventional iCCM guidelines.

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As malaria cases tend to cluster geographically and temporally[13-16], ASCs then proceeded with the RACD method to visit the home of an index case of confirmed malaria to find more cases who presented symptoms of malaria in the past week. These secondary cases or contacts would then be tested for free, classified and treated or referred to the nearest health centre in a similar way like the index case.

Data was collected using paper registers and later transcribed into a Microsoft Excel electronic database available as a Supplementary File 1. Data collected from the index case during PACD included: age, gender, place of residence, presence of fever, date of onset of fever, date and location seen by an ASC, results of RDT for malaria, severity of malaria and treatment received. During household visits, the same data were collected from febrile contacts in addition to data pertaining to household size, long-lasting treated bed nets ownership and current usage. Health facility malaria surveillance registers and ASC registers were used as sources to abstract data on malaria cases notified between 2015 and 2018.

Data analyses were performed using Stata version 14.2 (StataCorp. LP, College Station, United States of America) and Microsoft Excel 2016 (Microsoft Corporation, Redmond, USA) was used to plot curves. The data set was checked for logical inconsistencies, invalid codes, omissions and improbable data by tabulating, summarizing, describing and plotting variables, depending on their nature. Missing observations were systematically excluded.

The value of PACD and RACD over iCCM alone was measured by the proportion of additional cases detected.

To describe similarities or differences between index cases and contacts, summary statistics were presented as proportions for categorical variables, as means and standard deviations for normally distributed continuous variables and as medians and interquartile ranges (IQRs) for continuous variables with a skewed distribution. Associations between categorical variables were assessed using Pearson's χ^2 test or Fisher's exact test for small samples, as appropriate. For continuous variables, mean differences between index cases and contacts were assessed using Student's t test. Associations between exposure variables and the likelihood of finding a contact were evaluated by a univariate logistic regression model; crude odd ratios, 95% confidence intervals (CIs) were reported. Subsequently, factors associated with the odds of a finding a contact in the univariate analysis at a significance level below 5% were included in a multiple logistic regression model with mixed effects to account for the variability in CHW performance. Backward elimination based on a p-value lower than 0.05 was used to retain

variables that were independently associated with contact tracing; the corresponding adjusted odds ratios (aORs) and 95% CIs for the final model were reported.

In late May we conducted one comparative sweep of three purposefully selected neighbourhoods (Ebouh, Bareko, and B Bis) to assess how many cases of malaria were detected using our strategy relative to a full door-to-door sweep.

Patient and public involvement statement

As a community-led project, the public and patients were involved in the project planning, implementation and data collection.

The study was approved by the Cameroon National Ethics Review Committee and Peace Corps Cameroon. Individual and parental consent was sought and all information was anonymised and de-identified prior to analysis.

Results

Detection and management of febrile cases

At the end of the three-month pilot study, we screened a total of 501 febrile cases of whom 211 were index cases with a mean age of 3.4 ± 0.1 years who triggered a further screening by RACD of 290 contacts of mean age 19.9 ± 1.1 years (Table 1). Out of these index cases, 65 (30.8%) children from schools led to additional 55 (19.0%) cases, 36 (17.1%) from health facilities led to a further 35 (12.0%) cases, and 110 (52.1%) cases from the community led to 200 (69.0%) secondary cases. On average, index cases were reached within 2.4 ± 0.2 days after onset of fever. Of those screened, 65 index cases were likely to be boys (60.2%) while secondary cases were mostly girls under five years but no gender specificity among older secondary cases. The prevalence of malaria as demonstrated by a positive RDT, was very high in both the index (83.4%) and the secondary cases (85.9%). Of these 425 confirmed malaria cases, 354 (83.3%) were classified as uncomplicated malaria cases who received ACT immediately from the ASCs including 142 (67.3%) from the index cases and 212 (73.1%) from the secondary cases. The 147 cases who did not receive immediate ACT, were classified as either RDT negative in 76 (15.2%) or as having severe malaria in 71 (16.7%) cases. A total of 113 cases who did not receive ACT were referred to the nearest health centre for further management including all the remaining 35 RDT negative index cases and 78 secondary cases.

Characteristics		Index cases (n = 211)	Contacts (n = 290)	P-value of th difference betwee the groups
Reactive cases found per index case source				
	School	65 (30.8)	55 (19.0)	
	Health facility	36 (17.1)	35 (12.0)	
	Community	110 (52.1)	200 (69.0)	
	Total	211 (100)	290 (100)	< 0.001
Gender, n (%)				
	Male	127 (60.2)	144 (49.7)	
	Female	84 (39.8)	146 (50.3)	
	Total	211 (100)	290 (100)	0.019
Age, mean(SD) years		3.4 (0.1)	19.9 (1.1)	< 0.0001
Confirmed malaria, n (%)				
	RDT positive	176 (83.4)	249 (85.9)	
	RDT negative	35 (16.6)	41 (14.1)	
	Total	211 (100)	290 (100)	0.450
Immediate malaria treatment, n (%)				
	ACT	142 (67.3)	212 (73.1)	
	No ACT	69 (32.7)	78 (26.9)	
	Total	211 (100)	290 (100)	0.159
Referrals, n (%)				
· · · · ·	Yes	35 (16.6)	78 (26.9)	
	No	176 (83.4)	212 (73.1)	
	Total	211 (100)	290 (100)	0.006
Household size, mean (95%CI)		6.3 (6.0 - 6.5)	5,	
Household LLIN ownership, mean (95%CI)		2.3 (2.2 – 2.4)	1	
LLIN coverage per household member (95%CI)		0.37 (0.35 - 0.38)		
LLIN in use per household member (95%CI)		0.33 (0.31 – 0.35)		

Proactive and Reactive case detection of confirmed malaria

During the RACD triggered by 176 index cases of confirmed malaria in children under five, 132 (75%) of these index cases investigated led to at least one additional case of confirmed malaria and a total of 249 secondary cases identified within 176 households visited. After a lag phase during the first half of the project, the number of cases detected increased sharply over the second half before returning to the initial stable level (Figure 1).

Figure 1. Trend in the number of cases of confirmed malaria between April and June 2018

There were approximately 6 persons on average per household with a bed net ownership of about 2 LLINs per household leading to a bed net coverage of about 1 LLIN for 3 persons. Of all the 425 confirmed cases, 38 (8.9%) were index cases identified proactively in schools and led to find 50 (11.8%) more cases; 36 (8.5%) were index cases located in health facilities and led to a further 24 (5.6%) cases; and 102 (24.0%) were index cases identified during routine iCCM activity and led to 175 (41.2%) additional cases showing the value of RACD over iCCM alone (Figure 2). Overall, this active case detection (ACD) strategy based on PACD and RACD identified 287 of the 425 cases thus indicating that the ongoing iCCM must have been improved by 67.5% to manage malaria cases in the community.

Across these three neighbourhoods in May 2018, there was a total of 86 confirmed cases of malaria of whom our project found 50 while the door-to-door sweep caught an additional 36 cases. Thus, suggesting that this project succeeded at detecting 63% of the cases that could be captured by an exhaustive door-to-door strategy.

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Seasonally, across 12 weeks in April, May, and June in 2017 the ASCs detected 238 cases of malaria at a rate of ~20 cases per week. During our 8-week project across April, May and June in 2018, the ASCs detected 365 cases of malaria at a rate of ~45 cases per week computing to a 125% increase.

Figure 2. Relative contribution of active case detection strategies

The odds of finding a secondary case by RACD increased by 70% if the index case was one year younger (adjusted odd ratio (aOR) = 1.7, 95% CI: 1.5 - 1.9) and by 20% if a household increased by one person (aOR = 1.2, 95% CI: 1.1 - 1.3). Though RACD was likely to find female cases, the evidence to support gender discrimination was rejected in the multiple regression model in Table 2 (aOR = 1.2, 95% CI: 0.7 - 2.1).

1 2 3 4	Table 2
3 4 5 6 7 8 9 10	Factor
11 12 13	Gender
14 15	
16	
17 18	Additiona
19 20	year of ag
21	Additiona
22 23	household
24 25	member
26	
27 28	
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31 32	In thi
33	transn
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36 37	detect
38	childr
39 40	cases
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43	only t
44 45	this c
46 47	sugge
48	appear
49 50	strateg
51 52	experi
53	approa
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58	
59	

Table 2. Multiple logistic regression model of factors associated with secon	dary case detection (N = 425)
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Number of confirmed OR OR Crude Adjusted secondary p-value p-value (95%) (95%CI) cases, n (%) Male 124 (53.7) Reference Reference 0.024 1.2(0.7-2.1)125 (64.4) 1.6(1.1-2.3)0.477 Female l one 1.7(1.5 - 1.9)< 0.001 1.7 (1.5 - 1.9) < 0.001 e ıl one 1.2(1.1-1.3)< 0.0011.2(1.1-1.3)0.015

Discussion

is small-case quality improvement study, we sought to demonstrate in a high nission area, the feasibility of embedding both the proactive and reactive case detection gies into integrated community case management in order to maximise malaria case ion and prompt treatment. The study has indicated that by proactively searching for en under five years with malaria as index cases, and by reactively searching for more in the households of index cases, iCCM must have been improved by approximately 6. The study has also confirmed that the burden of malaria lies in the community with the tip of the iceberg seen in health facilities. While iCCM was introduced to respond to challenge, it was currently underperforming in this rural setting. This project has ested that iCCM can be adapted to achieve optimal results. While on one hand it may r obvious that the malaria component of iCCM can be adapted to or opt for a PACD gy, implementing RACD in a high transmission setting on the other hand may seem imental or even controversial to some extent. This is because RACD is a surveillance ach recommended in low transmission or pre-elimination settings to disrupt nission and is thought to be inefficient and unfeasible in high transmission settings. ersely, RACD may also waste time and money when cases are few and sporadic[17-20].

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Therefore, the choice of RACD as an approach depends on the objective to be attained, the proportion of cases it can detect and the resources needed. Our project was feasible and efficient because our aim was not to eliminate malaria but to detect and treat the maximum possible number of cases during a high transmission season when the proportion of cases is highest using resources already made available for iCCM in a rural setting where access to health services is limited. The extra resource needed is the time to visit schools, health facilities and households. CHWs told us that by conducting only a one-day visit per week to these facilities and only to households of index cases was more productive and made them more useful in their community. This strategy was not much different from what they were doing before, just a more targeted approach: - targeting schools, targeting households of index cases and targeting high transmission season when fever is likely to be caused by a *Plasmodium* infection as confirmed in this study where RDT was positive in 85% of persons screened for fever and with a probability of 75% that every index case led to at least one more case. Beyond CHW job satisfaction, teachers also expressed their satisfaction and were of great support in detecting fever or a history of fever amongst their pupils. Moreover, we found that teachers were far more likely to help CHW finding the households of sick children than healthcare workers. We thus strongly believe that RACD can be both feasible and efficient in a high transmission setting to maximise clinical case management. Consequently, we recommend that PACD and RACD become part of the ongoing iCCM strategy in Cameroon as an approach to optimise case detection. Yet incorporating PACD and RACD into iCCM will entail building a strong collaboration among CWH, HCW and teachers. Such a partnership already exists between the ministries of health and education in Cameroon in their concerted effort to fight neglected tropical diseases specifically soil-transmitted helminthiasis in school children[21]. The recurrent problem of stockouts of commodities will need to be resolved by the NMCP and field monitoring and supervision should become regular by iCCM programme coordination. Resolving these issues of multisector collaboration, delivery of commodities and field coordination were crucial as bottlenecks and explain in part why progress was slow in the first half of the project.

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This study has further indicated that, while index cases were likely to be boys, RACD was likely to find girls and women in univariate analysis though such claims were not supported by evidence from multivariate analysis. Boys make up the majority of school children in Cameroon especially in the rural areas and this might be a reflection of this observation[22]. However, it is plausible that gender norms and values that determine the division of labour,

leisure patterns, pregnancy, and sex-segregation of sleeping arrangements may lead to different patterns of exposure to mosquitoes for men and women[22-24].

Secondary cases were likely to be older than index cases and to be located in larger households of the index case. Given that we purposely targeted children under five years, it became obvious that we may likely find more of older children and adults as contacts. Clustering of cases has previously been demonstrated in households of the contacts and malaria eradication is thought to be feasible when household size drops below four persons [25, 26]. The average household size in this study was six persons thus explaining while it was very likely to find more cases in the community during RACD.

This study had some limitations so that the results should be interpreted with caution. The duration and period of the study was limited to only three months and to the first half of the wet season. We could not therefore account for neither seasonality in malaria transmission nor account for sustainability throughout the year. Older children and adults were not included as index cases thus creating an outright difference between index and secondary cases. This must have led to an overestimation of the value of RACD over iCCM in this field study because in routine practice however, adults would be index cases as well. Targeting school children for malaria treatment must have been a laudable effort but older school children were also left out as index cases though they constitute a group with a higher plasmodium infection prevalence than in the targeted younger age group[10]. However, these children were among those screened in the community. We did not measure the effect of this strategy on the pneumonia and diarrhoea components of iCCM but we believe that being an integral part of the package of interventions, these two components were likely to have been improved as well. We did not attempt to measure effect on malaria transmission as most studies have done.

Conclusion

This study has shown that most symptomatic cases of malaria remain undetected in the community despite the introduction of integrated community management of malaria. Schools are an important portal to locate children with undiagnosed malaria. Active case detection based on a proactive and reactive case detection approaches is feasible in a high transmission setting and has been shown to enhance in a synergistic manner the efficiency of integrated community case management of malaria. We recommend that national malaria

control programs adopt and implement this modified form of iCCM in similar settings to reduce the burden of malaria in our communities.

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Footnotes

Ethics approval and consent to participate

The study was approved by the National Ethics Review Board of Cameroon, Peace Corps Cameroon and local administrative and health authorities. Verbal consent was obtained from

household members after making public announcements and providing an information leaflets to explain the objectives of the project.

Consent for publication

Not Applicable

Availability of data and material

The datasets used and/or analysed during the current study are available as a supplementary file.

Competing interests

The authors declare that they have no competing interests

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Author Contributions

Conception, design and implementation: TDW, CEB

Data collection, analysis and interpretation: TDW, CEB

Drafting the manuscript: CEB

All authors read and approved the final manuscript

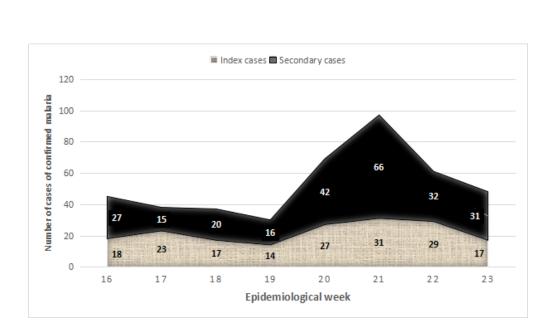
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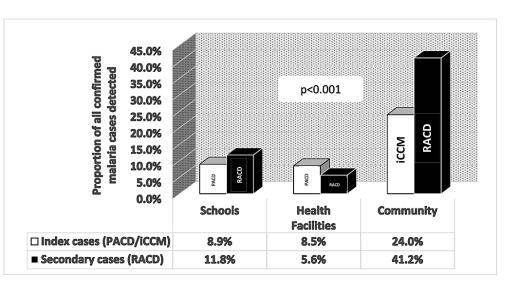
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1 2			assumptions that were used to develop the intervention(s), and reasons why the intervention(s) was expected to work	
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	Specific aims	<u>#6</u>	Purpose of the project and of this report	4
	Context <u>#7</u>		Contextual elements considered important at the outset of introducing the intervention(s)	4
10 11 12	Intervention(s)	<u>#08a</u>	Description of the intervention(s) in sufficient detail that others could reproduce it	5,6
14		<u>#08b</u>	Specifics of the team involved in the work	5
16 17 18	Study of the Intervention(s)	<u>#09a</u>	Approach chosen for assessing the impact of the intervention(s)	6,7
20 21 22		<u>#09b</u>	Approach used to establish whether the observed outcomes were due to the intervention(s)	6,7
23 24 25 26 27 28	Measures	<u>#10a</u>	Measures chosen for studying processes and outcomes of the intervention(s), including rationale for choosing them, their operational definitions, and their validity and reliability	6
29 30 31 32 33		<u>#10b</u>	Description of the approach to the ongoing assessment of contextual elements that contributed to the success, failure, efficiency, and cost	5,6
34 35 36 37		<u>#10c</u>	Methods employed for assessing completeness and accuracy of data	6
38 39 40 41	Analysis	<u>#11a</u>	Qualitative and quantitative methods used to draw inferences from the data	6,7
42 43 44 45		<u>#11b</u>	Methods for understanding variation within the data, including the effects of time as a variable	7
46 47 48 49 50	Ethical considerations	<u>#12</u>	Ethical aspects of implementing and studying the intervention(s) and how they were addressed, including, but not limited to, formal ethics review and potential conflict(s) of interest	7
51 52 53 54 55		<u>#13a</u>	Initial steps of the intervention(s) and their evolution over time (e.g., time-line diagram, flow chart, or table), including modifications made to the intervention during the project	n/a
56 57 58		<u>#13b</u>	Details of the process measures and outcome	n/a
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1 2		<u>#13c</u>	Contextual elements that interacted with the intervention(s)	5
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10 11 12		<u>#13f</u>	Details about missing data	6
13 14 15 16	Summary	<u>#14a</u>	Key findings, including relevance to the rationale and specific aims	10
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43 44 45	Conclusion	<u>#17a</u>	Usefulness of the work	12
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interpretation, and reporting

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Adding proactive and reactive case detection into the integrated community case management system (iCCM+) to optimise diagnosis and treatment of malaria in a high transmission setting of Cameroon

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Adding proactive and reactive case detection into the integrated community case management system (iCCM+) to optimise diagnosis and treatment of malaria in a high transmission setting of Cameroon Cavin Epie Bekolo^{1,2*}, Thomas D'Arcy Williams³ ¹Deapartment of Public Health, University of Dschang, P.O. Box 96 Dschang, Cameroon

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16 Key words

17 Malaria, integrated community case management, active case detection, Cameroon

1 2		
3	23	
4 5		
6 7	24	Abstract
8	25	Objective: Integrated community case management (iCCM) of childhood illness is a powerful
9 10	26	intervention to reduce mortality. Yet, less than 20% of children with fever in sub-Saharan
10	27	Africa have access to malaria testing. We conducted an action research to explore how iCCM+
12	28	based on incorporating proactive and reactive case detection of malaria into iCCM could help
13 14	29	accelerate coverage.
14	20	Design: A community lad grass socianal survey to measure the properties of <i>Diasmodium</i>
16 17	30 31	Design: A community-led cross-sectional survey to measure the proportion of <i>Plasmodium</i> infection detected under iCCM+ compared with iCCM alone.
18		
19	32	Setting: Four primary schools, 4 health facilities and 13 neighbourhoods of the rural
20 21	33	community of Bare-Bakem in Cameroon
22 23	34	Participants: Children and adults with fever between April and June 2018
24	35	Intervention: A modified iCCM programme (iCCM+) comprised of a proactive screening of
25 26	36	febrile children under five years old for malaria using rapid diagnostic testing to identify index
20	37	cases and a reactive screening triggered by these index cases to detect secondary cases in the
28	38	community
29 30	39	Primary and secondary outcome measures: The proportion of index and secondary malaria
31	40	cases detected by iCCM+ compared with iCCM alone.
32 33	41	Results: We screened a total of 501 febrile patients of whom <i>Plasmodium</i> infection was
34	41	confirmed in 425 (84.8%) cases including 176 (83.4%) index cases and 249 (85.9%) secondary
35 36		cases. Of these cases, 102 (24.0%) were index cases identified in the community during routine
37	43	
38	44 45	iCCM activity and 36 (8.5%) cases detected passively in health facilities; 38 (8.9%) were index
39	45 4C	cases identified proactively in schools; and 249 (58.6%) were additional cases detected in the
40 41	46 47	homes of index cases by RACD – computing to a total of 287 (67.5%) additional cases found by iCCM+ showing the added value of iCCM+ over iCCM alone.
42		
43 44	48	Conclusion: Most symptomatic cases of malaria remain undetected in the community despite
45	49	the introduction of community case management of malaria but most of these undiagnosed
46 47	50	cases can be mopped-up by iCCM+.
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55 Article Summary

56 Strengths and Limitations of this study

- The first study to show the clinical significance of a reactive case detection strategy in a high malaria transmission area
 - The study used existing community resources but in a more targeted manner to maximise access to malaria treatment in a poor and rural community
- A small-scale study with no control arm carried out during a relatively short period and during the high transmission season thus inclined towards over-estimating the value of the intervention

64 Introduction

In Cameroon, malaria-related morbidity has reduced from 40.6% in 2008 to 23.6% in 2016 while malaria proportionate mortality has reduced from 17.6% in 2000 to 12.4% in 2016[1-3]. Despite this remarkable effort, malaria remains a major public health problem in Cameroon where the entire population of more than 25 million inhabitants is at risk, with 71% living in high transmission areas[4]. In 2016, approximately 1.7 million malaria cases and 2637 deaths from malaria were recorded in health facilities in Cameroon. Children under five years of age were the most affected group in whom malaria was responsible for 41% of all-cause morbidity, 55% of hospital admissions and 69.7% of all malaria-attributed deaths in 2015[2]. To reduce childhood mortality, Cameroon and her development partners began implementing integrated community case management (iCCM) of pneumonia, diarrhoea, and malaria in 2009 to target communities with difficult access to health services. Community case management (CCM) of malaria can reduce overall mortality and malaria-specific under-five mortality by 40% and 60%, respectively, and severe malaria morbidity by 53%[5, 6]. Yet in 2011, less than 20% of children with fever in sub-Saharan Africa received a finger/heel stick for malaria testing[7]. In some localities of Cameroon, iCCM strategy has been reported to have increased treatment rate for malaria, increased care seeking for fever and reduced burden on healthcare facilities[8, 9]. However, data from a community needs assessment conducted in 2016 in the rural community of Bare-Bakem in the Littoral Region of Cameroon indicated that malaria represented up to 80% of all-cause morbidity across health centres and that iCCM has been facing significant challenges including: passive rather than active case detection; low uptake, underutilisation and attrition of trained community health workers (CHWs); prolonged and frequent stockouts of commodities for malaria diagnosis and treatment; inadequate supervision and motivation of CHWs. School children though typically constituting the group with the highest prevalence of

Plasmodium infection, have been virtually left out of this intervention despite receiving increasing attention recently [10-12]. In response to these challenges that threaten to reverse the initial iCCM gains, Peace Corps Cameroon has been supporting rural communities in Cameroon to effectively fight malaria. In 2018, the Peace Corps community of Bare-Bakem introduced a proactive and reactive case detection approach into the existing iCCM system with the objective to reduce malaria burden by expanding access to prompt malaria case management in the community. Integrating active (proactive and/or reactive) case detection strategy with iCCM has not yet been documented in high transmission settings. We report how in this community-led project, CHW proactively searched for cases of malaria in children under five in schools, health facilities and households; and then using index cases, they reactively detected and treated even more cases in the community by visiting the households of the sick children with confirmed malaria.

100 Methods

101 Design: A community-led cross-sectional survey to measure the proportion of *Plasmodium* 102 infection detected under iCCM+ compared with iCCM alone.

³¹₃₂ 103 Intervention

13 Intervention site and priority setting

The intervention was carried out in the rural town of Baré, the headquarters of Baré -Bakem municipality with a population of about 20000 inhabitants occupying a surface area of about 200km². Bare is situated at approximately 10 km from Nkongsamba (the divisional capital) and 120 km from the coastal city of Douala (the regional capital). It has 13 neighbourhoods: Bareko, Ebouth, Axe Lourd, A, A bis, B, B bis, C, D, E, E bis, F and F bis. The locality's low elevation and its warm and wet equatorial climate are conducive for high levels of malaria transmission. The town was host to a Peace Corps Volunteer (PCV) for the period between 2016 and 2018 with the mission to support efforts to fight infant and maternal mortality, malnutrition, malaria and HIV/AIDS. On average, across all the four health facilities in Baré, malaria made up approximately 40% of all sicknesses reported in 2016. Cases of malaria can even represent up to 80% of all sicknesses during the wet season. A Community Needs Assessment (CNA) carried out in December 2016 and January 2017 prior to the intervention indicated that malaria was the number one health priority for the community. Of the 250 people that were interviewed, 84% claimed that malaria was Baré's most important health problem. Malaria has a particularly devastating effect on children under the age of five, over 50% of consultations for children under five years old were confirmed cases of malaria. Despite the

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recognition that malaria is the community's top health priority – only 34% of participants could correctly explain the mode of transmission of malaria. Similarly, there is very limited access to health facilities and inadequate health-seeking behaviour for malaria treatment. About 80% of the population indicated that they initially seek care from traditional healers or road-side drug vendors. This is why a focus on malaria prevention and education is important but prompt and expanded access to malaria treatment so critical in Baré. The iCCM programme was introduced to respond to these needs but had its shortcomings that led to the implementation of iCCM+.

Intervention description and evaluation: Integrated Community Management Plus (iCCM+)

During 8 weeks of the high transmission period between April and June 2018, Baré's six CHWs locally known in French as "Agent de Santé Communautaire (ASC)" conducted an active malaria case detection (ACD) involving the addition of both the proactive case detection (PACD) phase and the reactive case detection (RACD) approaches into their existing iCCM activities. In operational terms, iCCM + = iCCM + PACD + RACD

Before launching, the project trained 25 primary and nursery school teachers on malaria detection and on the promotion of prevention & care seeking behaviour. Each CHW was assigned to a school and a collaborative system between teachers and ASCs working together to detect sick children was developed. Consent forms were distributed to the teachers to pass along to parents of pupils for their approval to test their children. Health care workers from the four health centres were also invited to the training in order to build working relations with CHWs. The CHWs had been trained repeatedly over the past years by the National Malaria Control Programme (NMCP) on community management of malaria, but they were briefed alongside two supervisors on the specificities of this project. One supervisor was in charge of correct data collection, while the other inspected schools and visited households to ensure completeness of field work.

PACD was undertaken in 12 primary & nursery schools, 4 health centres, and 13 community neighbourhoods on a weekly basis. Each week on a Thursday, CHWs visited assigned schools and health centres for a febrile screening. Upon arriving at their schools, the trained teachers will indicate the pupils under five who had a fever in a recent week (axillary temperature of 38°C or more). Health workers similarly helped to identify febrile children admitted in health facilities. Children with fever were identified and tested at no cost for Plasmodium infection

using rapid diagnostic tests (RDT) approved and supplied by the NMCP. Those tested positive for malaria were named as "index cases" and were further classified as either uncomplicated or severe malaria. Uncomplicated malaria cases were immediately treated with amodiaquine + artesunate, the first-line artemisinin-based combination therapy (ACT) recommended and supplied by the NMCP. Severe cases and RDT-negative cases were referred to health facilities for further investigation and management as per the NMCP guidelines. If a febrile child was absent from school the day the CHW arrived, the teacher would tell the CHW where the child lives. The CHW then visited the household to identify and test the sick child. In the community however, CHW continued to identify febrile children as per the conventional iCCM guidelines.

As malaria cases tend to cluster geographically and temporally[13-16], CHWs who also cluster and work in the neighbourhoods in which they live, then proceeded with the RACD method to visit the home of an index case. In the households, they made a list of all persons resident in the household (contacts of the index case), identified and tested those who had a fever in the past week. Those tested positive for malaria RDT were named as "secondary cases" and were also classified and treated or referred to the nearest health centre in a similar way like the index case as illustrated in Figure 1.

Figure 1. The flow chart of the augmented integrated community case management of malaria (iCCM+) (iCCM+)

Data was collected using paper registers and later transcribed into a Microsoft Excel electronic database available as a Supplementary File 1. Data collected from the index case during PACD included: age, sex, place of residence, presence of fever, date of onset of fever, date and location seen by an ASC, results of RDT for malaria, severity of malaria and treatment received. During household visits, the same data were collected from febrile contacts in addition to data pertaining to household size, long-lasting treated bed nets ownership and current usage. Health facility malaria surveillance registers and CHW registers were used as sources to abstract data on malaria cases notified between 2015 and 2018.

Data analyses were performed using Stata version 14.2 (StataCorp. LP, College Station, United States of America) and Microsoft Excel 2016 (Microsoft Corporation, Redmond, USA) was used to plot curves. The data set was checked for logical inconsistencies, invalid codes, omissions and improbable data by tabulating, summarizing, describing and plotting variables, depending on their nature. Missing observations were systematically excluded.

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The value of iCCM+ over iCCM alone was measured by the proportion of additional cases detected.

To describe similarities or differences between index and secondary cases, summary statistics were presented as proportions for categorical variables, as means and standard deviations for normally distributed continuous variables and as medians and interguartile ranges (IQRs) for continuous variables with a skewed distribution. Associations between categorical variables were assessed using Pearson's χ^2 test or Fisher's exact test for small samples, as appropriate. For continuous variables, mean differences between index cases and contacts were assessed using Student's t test. Associations between exposure variables and the likelihood of finding a contact were evaluated by a univariate logistic regression model; crude odd ratios, 95% confidence intervals (CIs) were reported. Subsequently, factors associated with the odds of a finding a contact in the univariate analysis at a significance level below 5% were included in a multiple logistic regression model with mixed effects to account for the variability in CHW performance. Backward elimination based on a p-value lower than 0.05 was used to retain variables that were independently associated with contact tracing; the corresponding adjusted odds ratios (aOR) and 95% CIs for the final model were reported.

Patient and public involvement statement

As a community-led project, the public and patients were involved in the project planning, implementation and data collection.

The study was approved by the Cameroon National Ethics Review Committee and Peace Corps Cameroon. Individual and parental consent was sought and all information was anonymised and de-identified prior to analysis. An information letter was sent to parents and local administrations, and was announced in community meeting or worshipping places.

Results

Detection and management of cases

At the end of the three-month pilot study, we screened a total of 501 febrile patients of whom *Plasmodium* infection was confirmed in 425 (overall prevalence of 84.8%) including 176 index cases with a mean age of 3.4 ± 0.1 years who triggered a further screening by RACD of 249 contacts of mean age 19.2 ± 1.2 years (Table 1). On average, index cases were reached within 2.4 ± 0.2 days after onset of fever. Index cases were mostly boys (60.8% vs. 49.8%, p = 0.025) while secondary cases were mostly girls under five years but no gender specificity among older secondary cases. The prevalence of malaria was very high in both the index (83.4%) and the

secondary cases (85.9%). Of these 425 confirmed malaria cases, 354 (83.3%) were classified
as uncomplicated malaria cases who received ACT immediately from the CHW. The 71 cases
who did not receive immediate ACT, were classified as severe malaria cases who were referred
to the nearest health centre for further management.

220 Table 1. Characteristics of index and secondary cases of malaria detected between April and June 2018

Characteristics		Index cases (n = 176)	Secondary cases (n = 249)	P-value of the difference betweer the groups of cases
Reactive cases found				
per index case source				
	School	38 (21.6)	50 (20.1)	
	Health facility	36 (20.4)	24 (9.6)	
	Community	102 (58.0)	175 (70.3)	
	Total	176 (100.0)	249 (100.0)	0.004
Sex, n (%)				
	Male	107 (60.8)	124 (49.8)	
	Female	69 (39.2)	125 (50.2)	
	Total	176 (100)	249 (100)	0.025
Age, mean (SD) years		3.4 (0.1)	19.2 (1.2)	<0.0001
Immediate malaria				
treatment, n (%)				
	ACT	142 (80.7)	212 (85.1)	
	No ACT	34 (19.3)	37 (14.9)	
	Total	176 (100)	249 (100)	0.225
Referrals, n (%)				
	Yes	34 (19.3)	37 (14.9)	
	No	142 (81.7)	212 (85.1)	
	Total	176 (100)	249 (100)	< 0.001
Household size, mean (95%CI)		6.4 (6.2 - 6.6)		
Household LLIN ownership, mean (95%CI)		2.4 (2.3 - 2.6)		
LLIN coverage per household member (95%CI)		0.38 (0.36 - 0.40)		
LLIN in use per household member (95%CI)		0.34 (0.32 – 0.36)	1	

60 222

Proactive and Reactive case detection of confirmed malaria

During the RACD triggered by 176 index cases of confirmed malaria in children under five, 132 (75%) of these index cases investigated led to at least one additional case and a total of 249 secondary cases identified from 290 febrile contacts within 176 households visited. There were approximately 6 persons on average per household with a bed net ownership of about 2 LLINs per household leading to a bed net coverage of about 1 LLIN for 3 persons. After a lag phase during the first half of the project, the number of cases detected increased sharply over the second half before returning to the initial stable level (Figure 2).

8 231 Figure 2. Trend in the number of cases of confirmed malaria between April and June 2018

Of all the 425 confirmed cases, 38 (8.9%) were index cases identified proactively in schools and led to find 50 (11.8%) more cases; 36 (8.5%) were index cases located in health facilities and led to a further 24 (5.6%) cases; and 102 (24.0%) were index cases identified during routine iCCM activity and led to 175 (41.2%) additional cases showing the value of RACD over iCCM alone (Figure 2). Overall, iCCM+ identified 287 of the 425 cases thus indicating that the ongoing iCCM must have been improved by 67.5% to manage malaria cases in the community (Figure 3).

3 239 Figure 3. Flow diagram of cases detected and treated during iCCM and iCCM+

During 12 weeks in April, May, and June in 2017 CHWs detected 238 cases of malaria at a rate of ~20 cases per week. But during our 8-week project across April, May and June in 2018, the CHWs detected 365 cases of malaria at a rate of ~45 cases per week computing to a 125% increase from 2017 during the same transmission season.

The odds of finding a secondary case by RACD increased by 70% if the index case was one year younger (adjusted odd ratio (aOR) = 1.7, 95% CI: 1.5 - 1.9) and by 20% if a household increased by one person (aOR = 1.2, 95% CI: 1.1 - 1.3). Though RACD was likely to find female cases, the evidence to support gender discrimination was rejected in the multiple regression model in Table 2 (aOR = 1.2, 95% CI: 0.7 - 2.1).

Factor		Number of confirmed secondary cases, n (%)	Crude OR (95%CI)	p-value	Adjusted OR (95%)	p-value
Sex						
	Male	124 (53.7)	Reference		Reference	
	Female	125 (64.4)	1.6 (1.1 – 2.3)	0.024	1.2 (0.7 – 2.1)	0.477
Additional one year of age	C		1.7 (1.5 – 1.9)	< 0.001	1.7 (1.5 – 1.9)	<0.001
Additional one household member		20	1.2 (1.1 – 1.3)	<0.001	1.2 (1.1 – 1.3)	0.015

250 Table 2. Multiple logistic regression model of factors associated with secondary case detection (N = 425)

Discussion

In this small-case quality improvement study, we sought to demonstrate in a high transmission area, the feasibility of embedding both the proactive and reactive case detection strategies into integrated community case management in order to maximise malaria case detection and prompt treatment. The study has indicated that by proactively searching for children under five years with malaria as index cases, and by reactively searching for more cases in the households of index cases, iCCM+ must have been increased the proportion of persons diagnosed and treated for *Plasmodium* infection by approximately 67.5%. The study has also confirmed that the burden of malaria lies in the community with only the tip of the iceberg seen in health facilities. While iCCM was introduced to respond to this challenge, it was currently underperforming in this rural setting. This project has suggested that iCCM can be adapted to achieve optimal results. While on one hand it may appear obvious that the malaria component of iCCM can be adapted to or opt for a PACD strategy, implementing RACD in a high transmission setting on the other hand may seem experimental or even controversial to some extent. This is because RACD is a surveillance approach recommended in low transmission or pre-elimination settings to disrupt transmission and is thought to be inefficient and unfeasible in high transmission settings. Conversely, RACD may also waste time and money when cases

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are few and sporadic[17-20]. Therefore, the choice of RACD as an approach depends on the

objective to be attained, the proportion of cases it can detect and the resources needed. Our

project was feasible and efficient because our aim was not to eliminate malaria but to detect

and treat the maximum possible number of cases during a high transmission season when the

proportion of cases is highest using resources already made available for iCCM in a rural

setting where access to health services is limited. The extra resource needed is the time to visit

schools, health facilities and households. CHWs told us that by conducting only a one-day visit

per week to these facilities and only to households of index cases was more productive and

made them more useful in their community. This strategy was not much different from what

they were doing before, just a more targeted approach: - targeting schools, targeting households

of index cases and targeting high transmission season when fever is likely to be caused by a

Plasmodium infection as confirmed in this study where RDT was positive in 85% of persons

screened for fever and with a high probability of 75% that every index case led to at least one

secondary case. Beyond CHW job satisfaction, teachers also expressed their satisfaction and

were of great support in detecting fever or a history of fever amongst their pupils. Moreover,

we found that teachers were far more likely to help CHW finding the households of sick

children than healthcare workers. We thus strongly believe that RACD can be both feasible

and efficient in a high transmission setting to maximise clinical case management.

Consequently, we recommend that PACD and RACD become part of the ongoing iCCM

strategy in Cameroon as an approach to optimise case detection. Yet incorporating PACD and

RACD into iCCM will entail building a strong collaboration among CWH, HCW and teachers.

Such a partnership already exists between the ministries of health and education in Cameroon

in their concerted effort to fight neglected tropical diseases specifically soil-transmitted

helminthiasis in school children[21]. The recurrent problem of stockouts of commodities will

need to be resolved by the NMCP and field monitoring and supervision should become regular

by iCCM programme coordination. Resolving these issues of multisector collaboration,

delivery of commodities and field coordination were crucial as bottlenecks and explain in part

This study has further indicated that, while index cases were likely to be boys, RACD was

likely to find girls and women in univariate analysis though such claims were not supported by

evidence from multivariate analysis. Boys make up the majority of school children in

Cameroon especially in the rural areas and this might be a reflection of this observation[22].

However, it is plausible that gender norms and values that determine the division of labour,

why progress was slow in the first half of the project.

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leisure patterns, pregnancy, and sex-segregation of sleeping arrangements may lead to different
patterns of exposure to mosquitoes for men and women[22-24].

Secondary cases were likely to be older than index cases and to be located in larger households of the index case. Given that we purposely targeted children under five years, it became obvious that we may likely find more of older children and adults as contacts. Clustering of cases has previously been demonstrated in households of the contacts and malaria eradication is thought to be feasible when household size drops below four persons [25, 26]. The average household size in this study was six persons thus explaining while it was very likely to find more cases in the community during RACD.

This study had some limitations so that the results should be interpreted with caution. There was no control arm to clearly distinguish between iCCM+ from iCCM intervention areas. A randomised community trial may be recommended as a solution. The duration and period of the study was limited to only three months and to the first half of the wet season. We could not therefore account for neither seasonality in malaria transmission nor account for sustainability throughout the year. Older children and adults were not included as index cases thus creating an outright difference between index and secondary cases. This must have led to an overestimation of the value of RACD in this field study because in routine practice however, adults would be index cases as well. Targeting school children for malaria treatment must have been a laudable effort but older school children were also left out as index cases though they constitute a group with a higher *Plasmodium* infection prevalence than in the targeted younger age group[10]. However, these children were among those screened in the community. We did not measure the effect of this strategy on the pneumonia and diarrhoea components of iCCM but we believe that being an integral part of the package of interventions, these two components were likely to have been improved as well. We did not attempt to measure effect on malaria transmission as most studies have done.

Conclusion

This study has shown that most symptomatic cases of malaria remain undetected in the community despite the introduction of integrated community management of malaria. Schools are an important portal to locate children with undiagnosed malaria. Active case detection based on a proactive and reactive case detection approaches is feasible in a high transmission setting and has been shown to enhance in a synergistic manner the efficiency of integrated community case management of malaria. We recommend that national malaria control

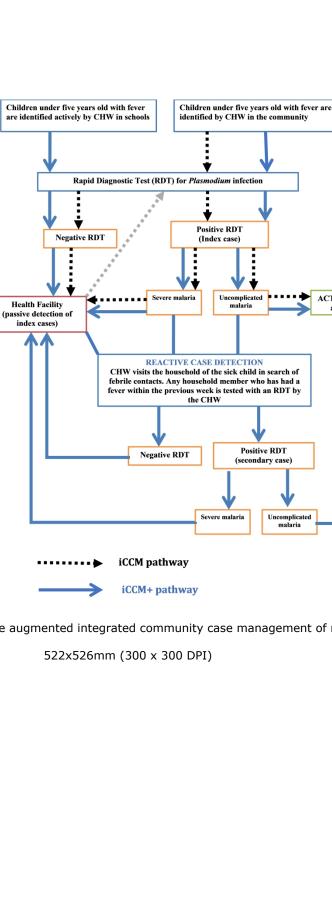
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- Footnotes
- - Ethics approval and consent to participate
- The study was approved by the National Ethics Review Board of Cameroon, Peace Corps
- Cameroon and local administrative and health authorities. Verbal consent was obtained from
- household members after making public announcements and providing an information leaflets
- to explain the objectives of the project.

1		
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5 6 7	426	Not Applicable
8 9	427 428	Availability of data and material
10 11	429	The datasets used and/or analysed during the current study are available as a supplementary
12 13 14	430	file.
15 16 17	431 432	Competing interests
18 19	433	The authors declare that they have no competing interests
20 21 22	434 435	Funding
23 24	436	The study received no specific funding
25 26 27	437 438	Author Contributions
28 29	439	Conception, design and implementation: TDW, CEB
30 31	440	Data collection, analysis and interpretation: TDW, CEB
32 33	441	Drafting the manuscript: CEB
34 35	442	All authors read and approved the final manuscript
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43 44	447	and collaboration.
45 46 47 48	448 449	Authors' information
49 50	450	CEB: Public Health Physician, Chief of Medical Centre of Bare – Bakem
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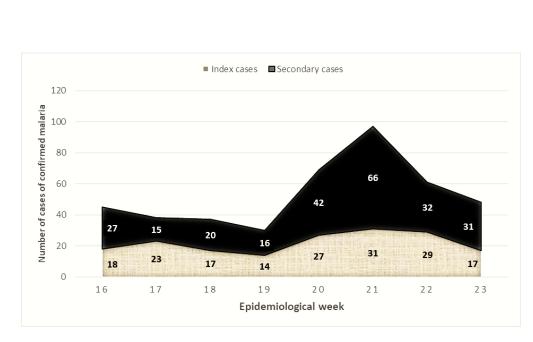


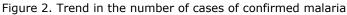
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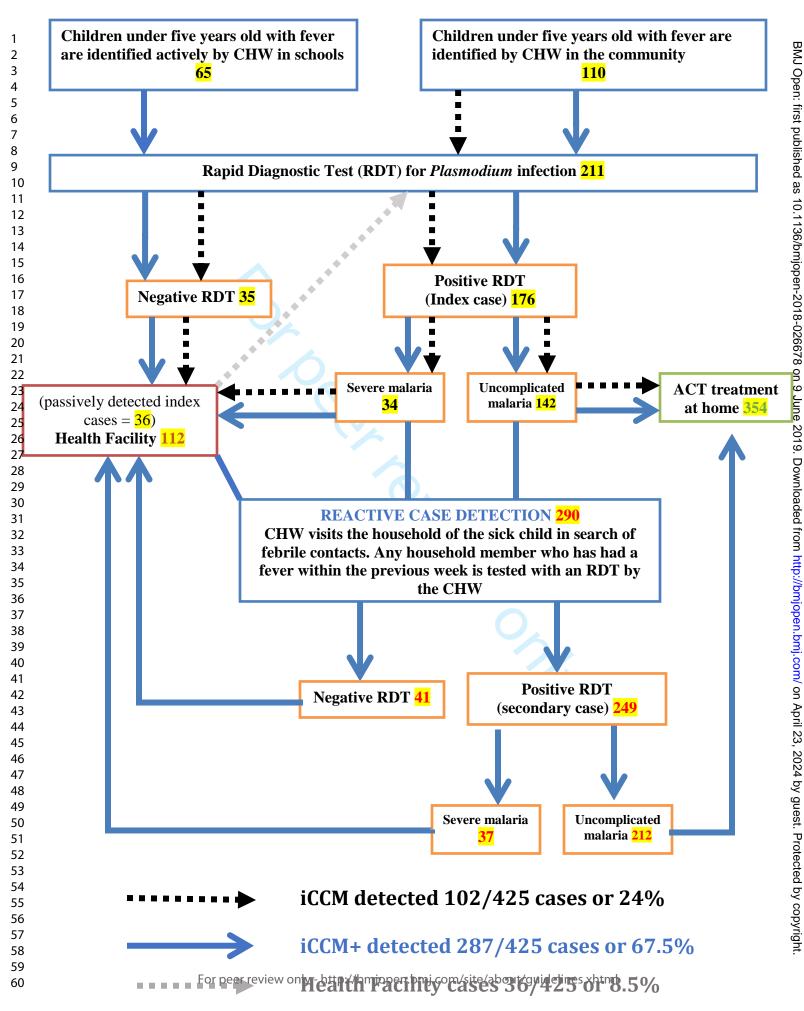
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Number	Case Number	Case Type Primary: 1 Secondary: 2	Age	Sex Male: 1 Female: 2	Quartier		RDT Result : Negative: 0 Positive: 1	given? No: 0 Yes: 1		Primary Case Location School: 1 Hospital: 2 Community: 3	Household	Total LUN	Total LLIN Attached	ASC	Week	Date of Fever	Date Found by ASC
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5	268	106.1	. 2	47	2	D :	1	1		3				MN MN	5		17/05/2018 17/05/2018	
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7	272 273	107	1	0.67	2	A Bis A Bis		0		2	4	1	1		5	16/05/2018	17/05/2018 17/05/2018	1
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13	286 287			62 2	1	A : F Bis :	1	1	0			2	2		5	15/05/2018	16/05/2018 16/05/2018	1
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16	292 293	118	1	45 2	1	F :		0	(3	1		L	5	02/05/2018	10/05/2018 10/05/2018	8
17	294 295	119	1	18	2	E :		0	(7	3	3	L	5	02/05/2018		8
18	296	120	1	38		A Bis	1	0			6	0		L		11/05/2018	10/05/2018 17/05/2018	6
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21	305	123.1	2	6 30	2	Ebouh Ebouh	. 1	1	(3				ZK	6		26/05/2018	
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23	309 310	124.1	2	57 30	2	Ebouh Ebouh	1	1						zk zk	6		24/05/2018 24/05/2018	
24	311 312	124.3	2	4	2	Ebouh :	0	1						zk zk	6		24/05/2018	3
25	313 314	127	1	4	1	Ebouh :	0	0		3	6	3	3		6	20/05/2018 23/05/2018	25/05/2018	4
26	315 316	127.2	2	5 31	2	E Bis E Bis		1		3				3N 3N	6		25/05/2018 25/05/2018	
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28	321	129.1	1	12		Bareko :		1		1		3	2			23/05/2018		2
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30	325 326 327	131	1	4	1	A Bis	1	1	(3	4	2	2			21/05/2018		2
31	328	131.2	2	6	2	A Bis :	1	1	(3				3N 3N	6		23/05/2018 23/05/2018 23/05/2018	
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35	336 337	136 136.1		4	1	A :	1	1	0			3		VIN VIN		23/05/2018		3
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36	340 341	137.1	. 2	3	1	Bareko : Bareko :		1	(3		4		VIN VIN	6	21/05/2018	23/05/2018	2
37	342 343	137.3	2	8	1	Bareko :		1	(3				MN MN	6		23/05/2018 23/05/2018	
38	344 345 346	137.5	2	59 12 5	2	Bareko : Bareko : B Bis :		1		3		3		MN MN MN	6		23/05/2018 23/05/2018	
39	340 347 348	138.1	. 2	30	2	B Bis B Bis	1	1		3		3		VIN VIN VIN	6		24/05/2018 24/05/2018 24/05/2018	4
40	349	138.3	2	42		B Bis :		1	0	3		2		MN MN	6		24/05/2018 24/05/2018 24/05/2018	4
41	351	139.1	. 2	9	2	B :	. 1	1	(3				MN MN	6		24/05/2018 24/05/2018	
42	353	139.3	2	4	1	B :	1	1	(3				MN MN	6		24/05/2018 24/05/2018	
43	355 356	139.5	2	34 5	1	B :		1		3		5	5	MN MN	6		24/05/2018	4
44	357 358	140.1	2	6	1	F B Bis	1	1	0	3		2		MN MN	6	20/05/2018	24/05/2018	4
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45	361 362		1	40 3	1		1	1	(3	7	4	1	MN MN		21/05/2018	24/05/2018 23/05/2018	2
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48	367 368 369	143.1	. 2	5 43 11	2	B :	. 1	1	(3		3		MN MN MN	6		21/05/2018	0
49	370		1	5	2	D :		1	(3		4	4	VIN VIN VIN		20/05/2018	21/05/2018 21/05/2018 21/05/2018	1
50	372	144.2	2	12	1	D :		1	(3				VIN VIN	6		21/05/2018 21/05/2018 21/05/2018	
51	374		2	15	1	D :	. 1	1	(3		2		MN MN	6		21/05/2018	0
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54	382 383	147.1 148	2 1	1	2	F Bis S	1	1	0	0 <u>3</u> 0 3	4	1	1		6	22/05/2018	20/05/2018 23/05/2018	1
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	Item No	Recommendation
Title and abstract	1	(<i>a</i>) Indicate the study's design with a commonly used term in the title or the abstract Page 2
		(<i>b</i>) Provide in the abstract an informative and balanced summary of what was done and what was found Page 2
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Page 3
Objectives	3	State specific objectives, including any prespecified hypotheses Page 4
Methods		
Study design	4	Present key elements of study design early in the paper Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment,
Setting	Ŭ	exposure, follow-up, and data collection Page 4-7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of
r	v	participants Page 5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect
	·	modifiers. Give diagnostic criteria, if applicable Page 6-7
Data sources/	8*	For each variable of interest, give sources of data and details of methods of
measurement		assessment (measurement). Describe comparability of assessment methods if there i
		more than one group Page 6-7
Bias	9	Describe any efforts to address potential sources of bias Page 6
Study size	10	Explain how the study size was arrived at Not calculated
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable,
		describe which groupings were chosen and why Page 7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
Page 7		(b) Describe any methods used to examine subgroups and interactions
		(c) Explain how missing data were addressed
		(<i>d</i>) If applicable, describe analytical methods taking account of sampling strategy
		(e) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially
		eligible, examined for eligibility, confirmed eligible, included in the study,
		completing follow-up, and analysed Page 7-8
		(b) Give reasons for non-participation at each stage Figure 1
		(c) Consider use of a flow diagram Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and
1		information on exposures and potential confounders Table 1
		(b) Indicate number of participants with missing data for each variable of interest
		Table 1
Outcome data	15*	Report numbers of outcome events or summary measures Tables 1 and 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and
		their precision (eg, 95% confidence interval). Make clear which confounders were
		adjusted for and why they were included Page 9 and Table 2
		(b) Report category boundaries when continuous variables were categorized
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a

		meaningful time period						
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Page 9						
Discussion								
Key results	18	Summarise key results with reference to study objectives Page 10						
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Page 11						
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Page 11						
Generalisability	21	Discuss the generalisability (external validity) of the study results Page 11-12						
Other information								
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Page 15						

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Adding proactive and reactive case detection into the integrated community case management system (iCCM+) to optimise diagnosis and treatment of malaria in a high transmission setting of Cameroon: an observational quality improvement study

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Keywords:	Malaria, integrated community case management, active case detection, Cameroon					



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Adding proactive and reactive case detection into the 1 integrated community case management system (iCCM+) 2 to optimise diagnosis and treatment of malaria in a high 3 transmission setting of Cameroon: an observational 4 quality improvement study 5

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Word Count: 3535 15

Key words 17

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r, Malaria, integrated community case management, active case detection, Cameroon 18

22 Abstract

Objective: Integrated community case management (iCCM) of childhood illness is a powerful intervention to reduce mortality. Yet, only 29% and 59% of children with fever in sub-Saharan Africa had access to malaria testing and treatment between 2015 and 2017. We report how iCCM+ based on incorporating active case detection of malaria into iCCM could help improve testing and treatment.

- 1213 28 Design: A community-led observational quality improvement study
- Setting: The rural community of Bare-Bakem in Cameroon
- Participants: Children and adults with fever between April and June 2018

Intervention: A modified iCCM programme (iCCM+) comprised of a proactive screening of
 febrile children under five years old for malaria using rapid diagnostic testing to identify index
 cases and a reactive screening triggered by these index cases to detect secondary cases in the
 community

- Primary and secondary outcome measures: The proportion of additional malaria cases
 detected by iCCM+ over iCCM.
- Results: We screened 501 febrile patients of whom Plasmodium infection was confirmed in 425 (84.8%) cases. Of these cases, 102 (24.0%) were index cases identified in the community during routine iCCM activity and 36 (8.5%) cases detected passively in health facilities; 38 (8.9%) were index cases identified proactively in schools; and 249 (58.6%) were additional cases detected by reactive case detection (RACD) – computing to a total of 287 (67.5%) additional cases found by iCCM+ over iCCM. The likelihood of finding additional cases increased with increasing family size [adjusted odd ratio (aOR) = 1.2, 95% CI: 54 1.1 - 1.3] and with increasing age [(aOR) = 1.7, 95% CI: 1.5 - 1.9].
- 45 Conclusion: Most symptomatic cases of malaria remain undetected in the community despite
 46 the introduction of community case management of malaria. iCCM+ can be adopted to
 47 diagnose and treat more of these undiagnosed cases especially when targeted to schools, older
 48 children and larger households.
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54 Article Summary

55 Strengths and Limitations of this study

- The first study to show the public health significance of a reactive case detection strategy in a high malaria transmission area
 - The study used existing community resources but in a more targeted manner to maximise access to malaria treatment in a poor and rural community
- A small-scale study with no control arm carried out during a relatively short period and during the high transmission season thus inclined towards over-estimating the value of the intervention

63 Introduction

In Cameroon, malaria-related morbidity has reduced from 40.6% in 2008 to 24.3% in 2017 while malaria proportionate mortality has reduced from 17.6% in 2000 to 12.8% in 2017¹⁻⁴. Despite this remarkable effort, malaria remains a major public health problem in Cameroon where the entire population of more than 25 million inhabitants is at risk, with 71% living in high transmission areas⁵. In 2016, approximately 1.7 million malaria cases and 2637 deaths from malaria were recorded in health facilities in Cameroon. Children under five years of age were the most affected group in whom malaria was responsible for 41% of all-cause morbidity, 55% of hospital admissions and 69.7% of all malaria-attributed deaths in 2015². To reduce childhood mortality, Cameroon and her development partners began implementing integrated community case management (iCCM) of pneumonia, diarrhoea, and malaria in 2009 to target communities with difficult access to health services. Community case management (CCM) of malaria can reduce overall mortality and malaria-specific under-five mortality by 40% and 60%, respectively, and severe malaria morbidity by 53%⁶⁷. Yet between 2015and 2017, only 59% of children with fever in sub-Saharan Africa received a malaria diagnostic test and only 29% had received any antimalarial drug⁸⁹. In some localities of Cameroon, iCCM strategy has been reported to have increased treatment rate for malaria, increased care seeking for fever and reduced burden on healthcare facilities¹⁰¹¹. However, data from a community needs assessment conducted in 2016 in the rural community of Bare-Bakem in the Littoral Region of Cameroon indicated that malaria represented up to 80% of all-cause morbidity across health centres and that iCCM has been facing significant challenges including: low uptake inherent to its passive nature, underutilisation and attrition of trained community health workers (CHWs); prolonged and frequent stockouts of commodities for malaria diagnosis and treatment; inadequate supervision and motivation of CHWs. School children though typically constituting the group

with the highest prevalence of *Plasmodium* infection, have been virtually left out of this intervention despite receiving increasing attention recently¹²⁻¹⁴. In response to these challenges that threaten to reverse the initial iCCM gains, Peace Corps Cameroon has been supporting rural communities in Cameroon to effectively fight malaria. In 2018, the Peace Corps community of Bare-Bakem introduced a proactive and reactive case detection approach into the existing iCCM system with the objective to reduce malaria burden by expanding access to prompt malaria case management in the community. Integrating active (proactive and/or reactive) case detection strategy with iCCM has not yet been documented in high transmission settings. We report how in this community-led project, CHW proactively searched for cases of malaria in children under five in schools, health facilities and households; and then using index cases, they reactively detected and treated even more cases in the community by visiting the households of the sick children with confirmed malaria.

Methods

Design: A community-led quality improvement study to measure the proportion of additional *Plasmodium* infection detected under iCCM+ compared with iCCM alone.

Intervention site and priority setting

The intervention was carried out in the rural town of Baré, the headquarters of Baré -Bakem municipality with a population of about 20000 inhabitants occupying a surface area of about 200km². Bare is situated at approximately 10 km from Nkongsamba (the divisional capital) and 120 km from the coastal city of Douala (the regional capital). It has 13 neighbourhoods: Bareko, Ebouth, Axe Lourd, A, A bis, B, B bis, C, D, E, E bis, F and F bis. The locality's low elevation and its warm and wet equatorial climate are conducive for high levels of malaria transmission. The town was host to a Peace Corps Volunteer (PCV) for the period between 2016 and 2018 with the mission to support efforts to fight infant and maternal mortality, malnutrition, malaria and HIV/AIDS. On average, across all the four health facilities in Baré, malaria made up approximately 40% of all sicknesses reported in 2016. Cases of malaria can even represent up to 80% of all sicknesses during the wet season. From a Community Needs Assessment (CNA) carried out in December 2016 and January 2017 prior to the intervention, 84% reported malaria as the most important health problem, but only 34% of respondents knew how malaria was transmitted. 80% of individuals reported first seeking care from traditional healers. The iCCM programme was introduced to respond to these needs but had its

shortcomings that led to the conception and implementation of iCCM+ as a modified iCCM

intervention. **Intervention description and evaluation Integrated Community Management (iCCM)** In 2016, as part of the ongoing nation-wide iCCM programme, CHW were trained, supplied and supervised to diagnose and treat children for malaria, pneumonia and diarrhoea, using artemisinin-based combination therapies, oral antibiotics, oral rehydration salts and zinc. Through home visits, patients of all ages in the community are screened for the 3 diseases and treatment is administered based on the results of the examination and diagnostic testing that includes malaria RDTs, disease history and respiratory rate. CHW also deliver health education and promotion talks during these home visits. There are no visits to schools and there is neither the proactive nor the reactive case detection effort. In this study, only the malaria component of iCCM was considered (Figure 1). **Integrated Community Management Plus (iCCM+)** During 8 weeks of the high transmission period between April and June 2018, Baré's six CHWs locally known in French as "Agent de Santé Communautaire (ASC)" conducted an active malaria case detection (ACD) involving the addition of both the proactive case detection (PACD) phase and the reactive case detection (RACD) approaches into their existing iCCM activities. In operational terms, iCCM + = iCCM + PACD + RACDBefore launching, the project trained 25 primary and nursery school teachers on malaria detection and on the promotion of prevention & care seeking behaviour. Each CHW was assigned to a school and a collaborative system between teachers and CHWs working together to detect sick children was developed. Consent forms were distributed to the teachers to pass along to parents of pupils for their approval to test their children. Health care workers from the four health centres were also invited to the training in order to build working relations with CHWs. The CHWs had been trained repeatedly over the past years by the National Malaria Control Programme (NMCP) on community management of malaria, but they were briefed alongside two supervisors on the specificities of this project. One supervisor was in charge of correct data collection, while the other inspected schools and visited households to ensure

- 149 completeness of field work.

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PACD was undertaken in 12 primary & nursery schools, 4 health centres, and 13 community neighbourhoods on a weekly basis. Each week on a Thursday, CHWs visited assigned schools and health centres to locate febrile children. Upon arriving at their schools, the trained teachers indicated the pupils under five who had a fever in a recent week. Health workers similarly helped to identify febrile children admitted in health facilities. Children with fever were identified and tested at no cost for *Plasmodium* infection using rapid diagnostic tests (RDT) approved and supplied by the NMCP. Those tested positive for malaria were named as "index cases" and were further classified as either uncomplicated or severe malaria. Uncomplicated malaria cases were immediately treated with amodiaquine + artesunate, the first-line artemisinin-based combination therapy (ACT) recommended and supplied by the NMCP. Severe cases and RDT-negative cases were referred to health facilities for further investigation and management as per the NMCP guidelines. If a febrile child was absent from school the day the CHW arrived, the teacher would tell the CHW where the child lives. The CHW then visited the household to identify and test the sick child. In the community however, CHW continued to identify febrile children as per the conventional iCCM guidelines.

As malaria cases tend to cluster geographically and temporally¹⁵⁻¹⁸, CHWs who also cluster and work in the neighbourhoods in which they live, then proceeded with the RACD method to visit the home of an index case. In the households, they made a list of all persons resident in the household (contacts of the index case), identified and tested those who had a fever in the past week. Those tested positive for malaria RDT were named as "secondary cases" and were also classified and treated or referred to the nearest health centre in a similar way like the index case as illustrated in Figure 1.

Figure 1. The flow chart of the augmented integrated community case management of malaria (iCCM+)

Data was collected using paper registers and later transcribed into a Microsoft Excel electronic database available as a Supplementary File 1. Data collected from the index case during PACD included: age, sex, place of residence, presence of fever, date of onset of fever, date and location seen by a CHW, results of RDT for malaria, severity of malaria and treatment received. During household visits, the same data were collected from febrile contacts in addition to data pertaining to household size, long-lasting treated bed nets ownership and current usage. Health facility malaria surveillance registers and CHW registers were used as sources to abstract data on malaria cases notified between 2015 and 2018.

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Data analyses were performed using Stata version 14.2 (StataCorp. LP, College Station, United
States of America) and Microsoft Excel 2016 (Microsoft Corporation, Redmond, USA) was
used to plot curves. The data set was checked for logical inconsistencies, invalid codes,
omissions and improbable data by tabulating, summarizing, describing and plotting variables,
depending on their nature. Missing observations were systematically excluded.

² 187 The value of iCCM+ over iCCM alone was measured by the proportion of additional cases 4 188 detected.

To describe similarities or differences between index and secondary cases, summary statistics were presented as proportions for categorical variables, as means and standard deviations for normally distributed continuous variables and as medians and interquartile ranges (IQRs) for continuous variables with a skewed distribution. Associations between categorical variables were assessed using Pearson's χ^2 test or Fisher's exact test for small samples, as appropriate. For continuous variables, mean differences between index cases and contacts were assessed using Student's t test. Associations between exposure variables and the likelihood of finding a contact were evaluated by a univariate logistic regression model; crude odd ratios, 95% confidence intervals (CIs) were reported. Subsequently, factors associated with the odds of a finding a contact in the univariate analysis at a significance level below 5% were included in a multiple logistic regression model with mixed effects to account for the variability in CHW performance. Backward elimination based on a p-value lower than 0.05 was used to retain variables that were independently associated with contact tracing; the corresponding adjusted odds ratios (aOR) and 95% CIs for the final model were reported.

Patient and public involvement statement

As a community-led project, the public and patients were involved in the project planning,implementation and data collection.

The study was approved by the Cameroon National Ethics Review Committee and Peace Corps Cameroon. Individual and parental consent was sought and all information was anonymised and de-identified prior to analysis. An information letter was sent to parents and local administrations, and was announced in community meeting or worshipping places.

Results

Detection and management of cases

At the end of the three-month pilot study, we screened a total of 501 febrile patients of whom Plasmodium infection was confirmed in 425 (overall test-positivity of 84.8%) including 176 index cases with a mean age of 3.4 ± 0.1 years who triggered a further screening by RACD of 249 contacts of mean age 19.2 ± 1.2 years (Table 1). On average, index cases were reached within 2.4 ± 0.2 days after onset of fever. Index cases were mostly boys (60.8% vs. 49.8%, p = 0.025) while secondary cases were mostly girls under five years but no gender specificity among older secondary cases. The RDT positivity for malaria was very high in both the index (83.4%) and the secondary cases (85.9%). Of these 425 confirmed malaria cases, 354 (83.3%) were classified as uncomplicated malaria cases who received ACT immediately from the CHW. The 71 cases who did not receive immediate ACT, were classified as severe malaria cases who were referred to the nearest health centre for further management.

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224	Table 1. Characteristics of index and secondary cases of malaria detected between April and June 2018

Characteristics		Index cases (n = 176)	Secondary cases (n = 249)	P-value of the difference between the groups of cases			
Reactive cases found per index case source		4					
	School	38 (21.6)	50 (20.1)				
	Health facility	36 (20.4)	24 (9.6)				
	Community	102 (58.0)	175 (70.3)				
	Total	176 (100.0)	249 (100.0)	0.004			
Sex, n (%)							
	Male	107 (60.8)	124 (49.8)				
	Female	69 (39.2)	125 (50.2)				
	Total	176 (100)	249 (100)	0.025			
Age, mean (SD) years		3.4 (0.1)	19.2 (1.2)	< 0.0001			
Immediate malaria treatment, n (%)							
	ACT	142 (80.7)	212 (85.1)				
	No ACT	34 (19.3)	37 (14.9)				
	Total	176 (100)	249 (100)	0.225			
Referred to health facility, n (%)							
	Yes	34 (19.3)	37 (14.9)				
	No	142 (81.7)	212 (85.1)				

	Total	176 (100)	249 (100)	< 0.001
Household size, mean (95%CI)		6.4 (6.2 - 6.6)		
Household LLIN ownership, mean (95%CI)		2.4 (2.3 – 2.6)		
LLIN coverage per household member (95%CI)		0.38 (0.36 – 0.4	40)	
LLIN in use per household member (95%CI)		0.34 (0.32 – 0.3	36)	

18 225

227 Proactive and Reactive case detection of confirmed malaria

During the RACD triggered by 176 index cases of confirmed malaria in children under five, 132 (75%) of these index cases investigated led to at least one additional case and a total of 249 secondary cases identified from 290 febrile contacts within 176 households visited. There were approximately 6 persons on average per household with a bed net ownership of about 2 LLINs per household leading to a bed net coverage of about 1 LLIN for 3 persons. After a lag phase during the first half of the project, the number of cases detected increased sharply over the second half before returning to the initial stable level (Figure 2).

Figure 2. Trend in the number of cases of confirmed malaria between April and June 2018

Of all the 425 confirmed cases, 38 (8.9%) were index cases identified proactively in schools and led to find 50 (11.8%) more cases; 36 (8.5%) were index cases located in health facilities and led to a further 24 (5.6%) cases; and 102 (24.0%) were index cases identified during routine iCCM activity and led to 175 (41.2%) additional cases showing the value of RACD over iCCM alone (Figure 2). Overall, iCCM+ identified 287 of the 425 cases thus indicating that the ongoing iCCM must have been improved by 67.5% to detect malaria cases in the community (Figure 3).

52 243 Figure 3. Flow diagram of cases detected and treated during iCCM and iCCM+

During 12 weeks in April, May, and June in 2017 CHWs detected 238 cases of malaria at a
rate of ~20 cases per week. But during our 8-week project across April, May and June in 2018,
the CHWs detected 365 cases of malaria at a rate of ~45 cases per week computing to a 125%
increase from 2017 during the same transmission season.

The odds of finding a secondary case by RACD increased by 70% if the index case was one year younger (adjusted odd ratio (aOR) = 1.7, 95% CI: 1.5 - 1.9) and by 20% if a household size increased by one person (aOR = 1.2, 95% CI: 1.1 - 1.3). Though RACD was likely to find female cases, the evidence to support gender discrimination was rejected in the multiple regression model in Table 2 (aOR = 1.2, 95% CI: 0.7 - 2.1).

Table 2. Multiple logistic regression model of factors associated with secondary case detection (N = 425)

Factor		Number of confirmed secondary cases, n (%)	Crude OR (95%CI)	p-value	Adjusted OR (95%)	p-value
Sex						
	Male	124 (53.7)	Reference		Reference	
	Female	125 (64.4)	1.6 (1.1 – 2.3)	0.024	1.2 (0.7 – 2.1)	0.477
Additional one year of age			1.7 (1.5 – 1.9)	<0.001	1.7 (1.5 – 1.9)	<0.001
Additional one household member			1.2 (1.1 – 1.3)	<0.001	1.2 (1.1 – 1.3)	0.015

Discussion

In this small-scale quality improvement study, we sought to demonstrate in a high transmission area, the feasibility of embedding both the proactive and reactive case detection strategies into integrated community case management in order to maximise malaria case detection and prompt treatment. The study has indicated iCCM+ increased the proportion of persons diagnosed and treated for *Plasmodium* infection by approximately 67.5%. The study has also confirmed that the burden of malaria lies in the community with only the tip of the iceberg seen in health facilities. While iCCM was introduced to respond to this challenge, it was currently underperforming in this rural setting. This project has suggested that iCCM can be adapted to achieve optimal results. While on one hand it may appear obvious that the malaria component

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of iCCM can be adapted to or opt for a PACD strategy, implementing RACD in a high transmission setting on the other hand may seem experimental or even controversial to some extent. This is because RACD is a surveillance approach recommended in low transmission or pre-elimination settings to disrupt transmission and is thought to be inefficient and infeasible in high transmission settings. Conversely, RACD may also waste time and money when cases are few and sporadic¹⁹⁻²². Therefore, the choice of RACD as an approach depends on the objective to be attained, the proportion of cases it can detect and the resources needed. Our project was feasible and efficient because our aim was not to eliminate malaria but to detect and treat the maximum possible number of cases during a high transmission season when the proportion of cases is highest using resources already made available for iCCM in a rural setting where access to health services is limited. The extra resource needed is the time to visit schools, health facilities and households. CHWs told us that by conducting only a one-day visit per week to these facilities and only to households of index cases was more productive and made them more useful in their community. This strategy was not much different from what they were doing before, just a more targeted approach: - targeting schools, targeting households of index cases and targeting high transmission season when fever is likely to be caused by a *Plasmodium* infection as confirmed in this study where RDT was positive in 85% of persons screened for fever and with a high probability of 75% that every index case led to at least one secondary case. Beyond CHW job satisfaction, teachers also expressed their satisfaction and were of great support in detecting fever or a history of fever amongst their pupils. Moreover, we found that teachers were far more likely to help CHW finding the households of sick children than healthcare workers. We thus strongly believe that RACD can be both feasible and efficient in a high transmission setting to maximise clinical case management. Consequently, we recommend that PACD and RACD become part of the ongoing iCCM strategy in Cameroon as an approach to optimise case detection. Yet incorporating PACD and RACD into iCCM will entail building a strong collaboration among CWH, HCW and teachers. Such a partnership already exists between the ministries of health and education in Cameroon in their concerted effort to fight neglected tropical diseases specifically soil-transmitted helminthiasis in school children²³. The recurrent problem of stockouts of commodities will need to be resolved by the NMCP and field monitoring and supervision should become regular by iCCM programme coordination. Resolving these issues of multisector collaboration, delivery of commodities and field coordination were crucial as bottlenecks and explain in part why progress was slow in the first half of the project. In response to the breakdown in the delivery of commodities, the regional office for the NMCP is now distributing these

commodities to health facilities and thus offsetting the transportation hurdles faced by the latter
to purchase and pick them up from their regional head offices of NMCP. Moreover, under the
ongoing performance-based financing (PBF) system, health facilities are becoming more and
more autonomous and can get their commodities from local authorised outlets.

This study has further indicated that, while index cases were likely to be boys, RACD was likely to find girls and women in univariate analysis though such claims were not supported by evidence from multivariate analysis. Boys make up the majority of school children in Cameroon especially in the rural areas and this might be a reflection of this observation²⁴. However, it is plausible that gender norms and values that determine the division of labour, leisure patterns, pregnancy, and sex-segregation of sleeping arrangements may lead to different patterns of exposure to mosquitoes for men and women²⁴⁻²⁶.

Secondary cases were likely to be older than index cases and to be located in larger households of the index case. Given that we purposely targeted children under five years, it became obvious that we may likely find more of older children and adults as contacts. Clustering of cases has previously been demonstrated in households of the contacts and malaria eradication is thought to be feasible when household size drops below four persons ^{27 28}. The average household size in this study was six persons thus explaining while it was very likely to find more cases in the community during RACD.

This study had some limitations so that the results should be interpreted with caution. There was no control arm to clearly distinguish between iCCM+ from iCCM intervention areas. A randomised community trial may be recommended as a solution. The duration and period of the study was limited to only three months and to the first half of the wet season. We could not therefore account for neither seasonality in malaria transmission nor account for sustainability throughout the year. Older children and adults were not included as index cases thus creating an outright difference between index and secondary cases. This must have led to an overestimation of the value of RACD in this field study because in routine practice however, adults would be index cases as well. Targeting school children for malaria treatment must have been a laudable effort but older school children were also left out as index cases though they constitute a group with a higher *Plasmodium* infection prevalence than in the targeted younger age group¹². However, these children were among those screened in the community. We did not measure the effect of this strategy on the pneumonia and diarrhoea components of iCCM but we believe that being an integral part of the package of interventions, these two components

were likely to have been improved as well. We did not attempt to measure effect on malariatransmission as most studies have done.

334 Conclusion

This study has shown that most symptomatic cases of malaria remain undetected in the community despite the introduction of integrated community management of malaria. Schools are an important portal to locate children with undiagnosed malaria. Active case detection based on a proactive and reactive case detection approaches is feasible in a high transmission setting and has been shown to enhance in a synergistic manner the efficiency of integrated community case management of malaria. We recommend that national malaria control programs adopt and implement this modified form of iCCM in similar settings to diagnose and treat more malaria cases in our communities.

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13 14	431	
15 16	432	Footnotes
17		roothotes
18	433	
19	434	Ethics approval and consent to participate
20 21	435	
22 23	436	The study was approved by the National Ethics Review Board of Cameroon, Peace Corps
24	437	Cameroon and local administrative and health authorities. Verbal consent was obtained from
25 26	438	household members after making public announcements and providing an information leaflets
27 28	439	to explain the objectives of the project.
29 30	440	Consent for multipotion
31	440	Consent for publication
32	441	Not Applicable
33 34		
35	442	Availability of data and material
36	443	
37		9
38 30	444	The datasets used and/or analysed during the current study are available as a supplementary
39 40	445	file.
41		Competing interests
42	446	Competing interests
43 44	447	
44 45	440	The such and dealers that there have no economic interaction
46	448	The authors declare that they have no competing interests
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58 59	-55	
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13		
14 15	463	Authors' information
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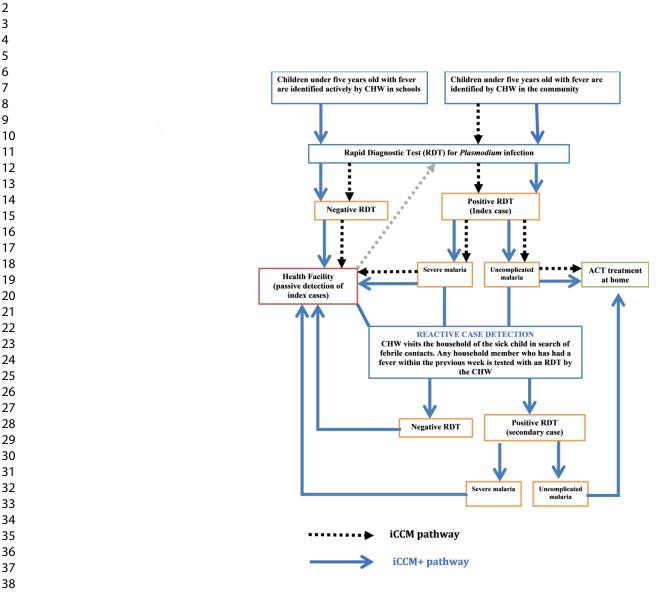


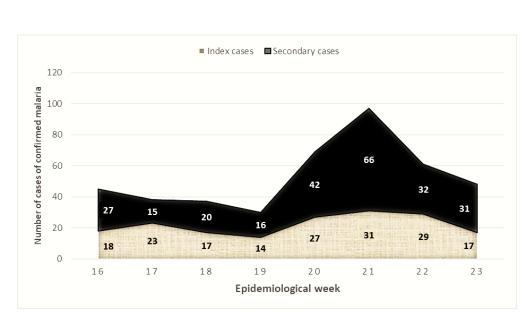
Figure 1. The flow-chart of the augmented integrated community case management of malaria (iCCM+)

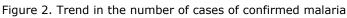
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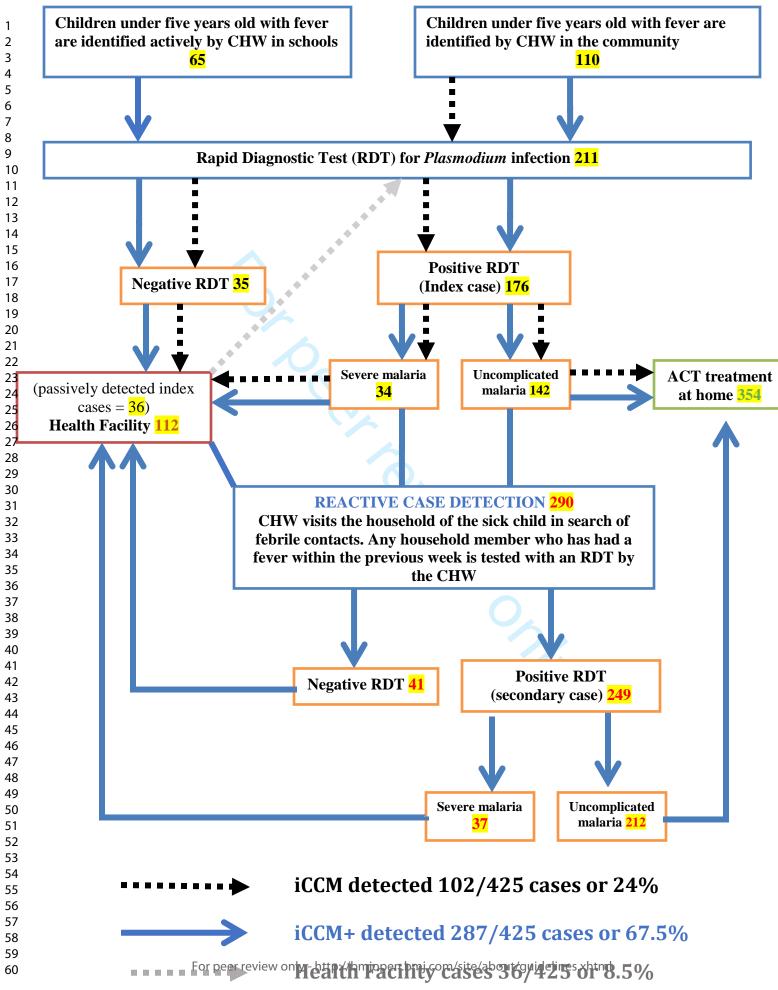
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79x43mm (300 x 300 DPI)



Number	Case Number	Case Type Primary: 1 Secondary: 2	Age	Sex Male: 1 Female: 2	Quartier	Fever? No: 0 Yes: 1	RDT Result Negative: 0 Positive: 1	If simple malaria, ACT given? No: 0 Yes: 1 Refused: 2		Primary Case Location School: 1 Hospital: 2 Community: 3	Household	Total LUN	Total LLIN Attached	ASC	Week	Date of Fever	Date Found by ASC	How took?
1	1.1	1	10	1	B Bis B Bis	1				2		3		YL YL	1	l 16/04/2018	19/04/2018 19/04/2018	
3		2		1	B Bis B Bis	0	0	0	C	2				YL YL	1	L	19/04/2018 19/04/2018	
5		1			Bareko Bareko	1			0			2		YL YL	1	L 17/04/2018	19/04/2018 19/04/2018	
7		2			Bareko Ebouh	0						5		JY ZK	1		19/04/2018 19/04/2018	
9 10	3.1 3.2	2		1	Ebouh Ebouh	1	1	0						ZK ZK	1	L	19/04/2018 19/04/2018	
11 12	4	1	. 5	1	Ebouh Ebouh	1						4	4	ZK ZK	1	l 16/04/2018	19/04/2018 19/04/2018	
13 14	4.2	2	12	1	Ebouh Ebouh	1				. 1				ZK ZK	1	L	19/04/2018 19/04/2018	
15	4.4	2	5	2	Ebouh Ebouh	1	1	1	C	1				ZK ZK	1		19/04/2018 19/04/2018	
17	5	1	. 5	2	Ebouh	1	1	1	C	1	15	0	0	ZK ZK ZK		L 16/04/2018	19/04/2018	
18	5.2	2	10	1	Ebouh Ebouh	1	1	0	1	. 1				ZK	1	L	19/04/2018 19/04/2018	<u> </u>
20	6	2	. 4	1	Ebouh Ebouh	1	1	1	C	1	4	2	2	ZK ZK		L 15/04/2018	19/04/2018 19/04/2018	
22	7	2	. 5	2	Ebouh Ebouh	1	1	1	C	1	6	6	6	ZK ZK		10/04/2018	19/04/2018 19/04/2018	
24 25	7.2	2	28	2	Ebouh Ebouh	1	1	0	1	. 1				ZK ZK	1	t	19/04/2018 19/04/2018	
26 27	8.1		2	1	Ebouh Ebouh	1	1	1	C	1		3		ZK ZK	1	l 15/04/2018	19/04/2018 19/04/2018	
28 29	10	1	. 4	2	Ebouh Ebouh	1	-			1	6	4	2	ZK ZK	1	13/04/2018 15/04/2018		
30 31		1			Ebouh Ebouh	1	1		C			4		ZK ZK		13/04/2018 16/04/2018		
32	13	1			B Bis B Bis	1	0					2		ZK JL	1	15/04/2018 19/04/2018	19/04/2018 21/04/2018	
34 35		2			B Bis B Bis	1	0							JL JL		L	21/04/2018	_
36 37	14.3	2	19	2	B Bis	1			1	. 3		4		JL MN	1	l l 17/04/2018	21/04/2018 19/04/2018	
38	15.1	2		2	F	1	1	1	C	3				MN MN		L	19/04/2018 19/04/2018	_
40	15.3	2	18	1	F	0	0	0	C	3				MN	1	1	19/04/2018 19/04/2018	
42	15.5	2	12	2	F	1	0	0	1	. 3				MN MN		L	19/04/2018	_
43	15.7	2	8	1	F	0	0	0	C	3				MN	1	L	19/04/2018 19/04/2018	
45	16	2	. 4	2	E	0	0	0	1	. 3				MN MN		19/04/2018	19/04/2018 19/04/2018	L
47		1	5	1	E	1	1	1	C	3		4		BN BN	1		21/04/2018 21/04/2018	
49 50	17.3	2	50	1		1	0	0	C	3				BN BN	1	L	21/04/2018 21/04/2018	
51 52	18	2			E	0						6		BN BN	1		21/04/2018 21/04/2018	
53 54		2			E	0								BN BN	1		21/04/2018 21/04/2018	
55 56	18.3	2		1	E	1			C	3				BN BN	1		21/04/2018 21/04/2018	
57 58	19	1	. 4	1		1	1	1	0	1	7	3		RT		18/04/2018	19/04/2018 19/04/2018	<u> </u>
59	19.2	2	50	2	E	1		0	1	. 1				RT		L	19/04/2018 19/04/2018	_
61 62	19.4	2	11	. 2	E	1	1	0	1	. 1				RT	1	L	19/04/2018 19/04/2018	<u> </u>
63 64	19.6	2	7	2	E	1				. 1				RT	1		19/04/2018 19/04/2018 19/04/2018	_
65	20.1	2	30	1	F	0	0	0	C	1		2		RT	1	L	19/04/2018	<u> </u>
66	20.3	2	18	2	F	0	0	0	C	1				RT RT	1	L	19/04/2018 19/04/2018	L
68 69	21	2	. 3	2	E Bis	1	1	1	C	1	4	2	1	RT JY		2 25/04/2018	19/04/2018 25/04/2018	
70 71	22	2	. 3	2	E Bis F	0	0	0	1	. 1				YL YL	2	2 23/04/2018	25/04/2018 26/04/2018	
72	23.1	1			A Bis A Bis	1						3		YL	2	2 22/04/2018	28/04/2018	
74	24	2	. 5	2	A Bis Bareko	1	1	0	C		No Visit			YL	2	2 23/04/2018	28/04/2018 28/04/2018	
76		1			Bareko Ebouh	1					No Visit 6	3		JY ZK		2 23/04/2018 2 20/04/2018		_
78 79		2			Ebouh Ebouh	1								ZK ZK			24/04/2018 24/04/2018	
80 81	27	1	. 4	1	Ebouh Ebouh	1		1	C	1				ZK ZK	1	2 23/04/2018	26/04/2018 26/04/2018	
82 83	28	1			Ebouh Ebouh	1	1	1	C			3		ZK ZK	1			
84	29	1	. 5	2	Ebouh Ebouh	1		1	c	1	6	3	3	ZK ZK		2 20/04/2018		
86	30	1	. 5	2	Ebouh Ebouh	1	0	0	1	. 1				ZK ZK	2	2 23/04/2018 2 21/04/2018	26/04/2018	
88	32	1	. 4	2	F Bis F Bis	1		1	C	3	7	3	2	1L 1L		2 21/04/2018		_
90 91	32.2	2	3	2	F Bis F Bis	1	1	1	C	3				л. Л.		2	28/04/2018 28/04/2018 28/04/2018	<u> </u>
92	33	1	. 3	1	Axelourd	1	1	0	c	2	7	0	0	MN	3	2 25/04/2018	26/04/2018	<u> </u>
93 94	33.2	2	6	2	Axelourd Axelourd	1	0	0	1	. 2				MN MN	2	2	26/04/2018 26/04/2018	
95 96	33.4	2	11	1	Axelourd Axelourd	1	0	0	1	. 2				MN MN	2	2	26/04/2018 26/04/2018	
97 98	33.5	2			Axelourd B	1	-					0		MN MN	1		26/04/2018 26/04/2018	
99 100		2	. 5	1	B F	0	0					4	4	MN MN	2	2 23/04/2018	26/04/2018 26/04/2018	
101	35.1 36	2		1	F	1					5	2		MN MN	1	2 26/04/2018	26/04/2018 26/04/2018	
103 104	36.1	2		2	F	1								MN MN	1	2	26/04/2018 26/04/2018	
105 106		1	. 2	1	F	1	1	1	C	3	9	4	0	MN MN	1	2 23/04/2018	26/04/2018 26/04/2018	
107	38	1	. 4	2	E	1	1	1	C	3	4	2	2	BN BN		2 25/04/2018	29/04/2018 29/04/2018	<u> </u>
109	39	1	. 2	2	В	1	1	1	C	3	8	4	4	RT	2	2 24/04/2018	25/04/2018	<u> </u>
110	39.2	2	5	1	B B	1	1	1	C	3				RT RT		2	25/04/2018 25/04/2018	
112	40	2	. 5	1	B D	0	1	1	c	1	3	1	1	RT RT		2 24/04/2018		L
114 115	40.2	2	51	. 2	D D	1		0	C	1				RT RT	1	2	25/04/2018 25/04/2018	L
116 117	42	1	. 2	1	B Bis	1		0		. 1		1		RT RT	2	2 24/04/2018 2 25/04/2018	26/04/2018	F
118 119	43.1	1	5	2	c c	1			1	3	9	4		RT RT	1	2 25/04/2018	26/04/2018 26/04/2018	F
120 121		2			c c	1	0			. 3				RT RT	1		26/04/2018 26/04/2018	-
122	43.4	2	11	2	c c	1	1	0	1	. 3				RT		2	26/04/2018 26/04/2018	<u> </u>
123		2	26	1	C	0	0	0	C	3				RT			26/04/2018 26/04/2018	1
125		1			B Bis	1					7	4		RT		17/04/2018	25/04/2018	1

128	45.1	2	5	2 B Bis	1	1	1 0	1		1		RT	2	1	26/04/2018	1
129 130	45.2 46	2	14 4	2 B Bis 2 E Bis	0	0 0	0 0	1	2	2	2		2	26/04/2018	26/04/2018 26/04/2018	
131 132 133	46.1 47 47.1	2	36 1 45	2 E Bis 1 B 2 B	0	0 0	0	3	4	2	2	RT JL JL		02/05/2018	26/04/2018 03/05/2018 03/05/2018	
134	48	1	5 60	1 B 1 B	1	1 0 0	0	3	4	1	1	JL	3	02/05/2018	03/05/2018	
136 137	49 49.1	2	2	1 Bareko 1 Bareko		1 :		2		2		MN MN	3	03/05/2018	03/05/2018 03/05/2018	
138 139	50 50.1	2	5 9	1 B Bis 2 B Bis		1 0) 1	2		2		MN MN	3		03/05/2018	
140 141 142	50.2 50.3 51	2	3 11 3	2 B Bis 1 B Bis 1 B	1	1 0) 1	2		4		MN MN MN	3	02/05/2018	03/05/2018	
142	51.1 52	2	9	1 B 1 F	1	1 () 1	2		4		MN	3		03/05/2018	
145 146	52.1 52.2	2	4 7	2 F 2 F	1	1 1	0	2				MN	3		03/05/2018 03/05/2018	
147 148	52.3 53	1	10 5	2 F 2 D	1	1 0	0 0	2	4	0	0	MN MN	3	02/05/2018	03/05/2018 03/05/2018	
149 150	53.1 53.2	2	2 0.17	2 D 1 D	1	1 1	0	2				MN MN	3		03/05/2018 03/05/2018	
151	54 54.1 55	1 2 1	0.58 27 4	2 Bareko 2 Bareko 1 E	1	1 (1 (1 () 1	2	8	4		MN MN MN	3	02/05/2018	03/05/2018	
153 154 155	55.1 56		2	1 E 1 Bareko	1	1 1	0	2		6		MN BN	3	02/05/2018	03/05/2018	
156 157	56.1 56.2	2	5	1 Bareko 1 Bareko	1	1 :	0 0					BN BN	3		03/05/2018 03/05/2018	
158 159	56.3 56.4	2	10 18	2 Bareko 2 Bareko	0	1 0	0 0	2				BN BN	3		03/05/2018 03/05/2018	
160 161	57 57.1		3 14	2 Ebouh 1 Ebouh	1) 1	1		2		ZK	3		03/05/2018	
162 163 164	58 58.1 59	1 2 1	3 8 5	1 Ebouh 2 Ebouh 1 B Bis	1	1 1 1 0) 1	1		2		ZK	3	01/05/2018	03/05/2018	
165	59.1 60		30	2 B Bis 1 Ebouh		1 () 1	1		2		ZK	3	01/05/2018	03/05/2018	
167	60.1 61	2	5 35 5	2 Ebouh 1 Ebouh	1	0 0) 1	1				ZK ZK	3		03/05/2018	
169 170	62 63	1	3	1 Ebouh 2 D	1	0 0	0 1 L 0	1	5	2	1	ZK RT	3	02/05/2018 02/05/2018	03/05/2018 02/05/2018	
171 172	63.1 63.2		5 2	2 D 1 D		1 0) 1	3				RT RT	3		02/05/2018 02/05/2018	
173	64 64.1		4 3 2	1 F Bis 1 F Bis	1	1 0 0) 1	1	5	2		RT	3	27/04/2018	03/05/2018	
175 176 177	65 66 67	1	2	2 B 2 B 1 B Bis	1	0 0) 1		6	3			3	03/05/2018 03/05/2018	03/05/2018	
178	68 69	1	5	1 D 1 A	1	0 (1				RT	3	02/05/2018	03/05/2018	
180 181	70 70.1		3	1 E 2 E	1	1 0	0 0	2		0	0			28/04/2018		
182 183	70.2 71	1	3	1 E 2 B		1	0	3	5	3	3	JY MN	3	06/05/2018		
184	71.1	2	8 4 3	1 B 1 F	1	1 (1 0	3		2	2	MN MN	4	08/05/2018		
186 187 188	72.1 72.2 72.3	2	5	1 F 2 F 1 F	1	1		3				MN MN MN	4		10/05/2018 10/05/2018 10/05/2018	
189	73	1	1	1 F 2 F	1	0 0) 1	3				MN MN	4	05/05/2018	10/05/2018	
191 192	75 75.1	1 2	4	2 Bareko 1 Bareko	1	1	L 0	3		0	0	MN MN	4	07/05/2018	10/05/2018 10/05/2018	
193 194	75.2 75.3	2	3	2 Bareko 2 Bareko	1	1	0	3				MN MN	4		10/05/2018 10/05/2018	
195 196 197	76 76.1 76.2		5 0.5 3	2 Bareko 1 Bareko 1 Bareko	1 1	1 1		3		5		MN MN MN	4		10/05/2018 10/05/2018 10/05/2018	
198	76.3	2	2	1 Bareko 1 Bareko	1	1 1	1 0	3				MN	4		10/05/2018 10/05/2018 10/05/2018	
200	77 77.1	1	2	2 E 2 E	1	1	0	3				BN BN	4	10/05/2018	10/05/2018 10/05/2018	
202 203	78 78.1		2	2 A 2 A	1	1	0	3				BN BN	4		11/05/2018	
204	79 79.1	1 2 1	3 22 4	1 E Bis 2 E Bis	1 1 1	1 0 0) 1	1		4		RT RT	4		03/05/2018	
206 207 208	80 81 81.1	1	2	2 D 2 A 1 A	1	1			5	4				01/05/2018 09/05/2018		-
209	82	1	5 4	2 A 1 Ebouh	1	1 1			5	3	2			10/05/2018 07/05/2018	11/05/2018	
211 212	83.1 83.2	2	6 3	1 Ebouh 1 Ebouh		1 0	1	1				ZK ZK	4		10/05/2018 10/05/2018	
213 214	84 84.1	2	27	1 B Bis 2 B Bis		1 0 0) 1	3		3		ZK	4		10/05/2018	
215 216 217	85 86 86.1	1	5 5 35	1 Ebouh 1 Ebouh 2 Ebouh	1	0 0	1 0	1	5	3	3	ZK ZK ZK	4	09/05/2018	10/05/2018 10/05/2018 10/05/2018	
218 219	87	1	5	1 Ebouh 1 Ebouh	1		0 1	1				ZK ZK	4	07/05/2018	10/05/2018	
220 221	89 89.1		4 45	2 F 1 F	1	1 0) 1	3	5	2		JL	4	06/05/2018	07/05/2018 07/05/2018	
222 223	89.2 90	1	15 3	1 F 2 Ebouh	1	1 :		3	6	3	3			14/05/2018		
224 225 226	90.1 90.2 90.3	2 2 2	6 61 6	2 Ebouh 1 Ebouh 1 Ebouh	1	1 1 1	0	3				ZK ZK ZK	5		15/05/2018 15/05/2018 15/05/2018	
220	90.3 91 91.1	1	2	1 Ebouh 1 Ebouh 1 Ebouh	1	1 1	0	1	6	3	3		5	15/05/2018	17/05/2018 17/05/2018	
229 230	91.2 92	2	56 3	2 Ebouh 1 Ebouh	1	1	L 0	1	8	3	3	ZK ZK	5		17/05/2018 17/05/2018	
231 232	92.1 92.2	2	60 10	1 Ebouh 1 Ebouh		1	1 0	1				ZK ZK	5		17/05/2018 17/05/2018	
233 234 235	92.3 93 93.1	1	16 3 8	1 Ebouh 1 Ebouh 2 Ebouh	1	1	0	1	6	3	3	ZK ZK ZK	5	14/05/2018	17/05/2018 17/05/2018 17/05/2018	
236	93.2		58	2 Ebouh 1 E	1	1 0 0	0	1				ZK ZK	5		17/05/2018	
238 239	95 96	1	3	2 Ebouh 1 Ebouh	1	0 0	1	1				ZK ZK	5	15/05/2018 14/05/2018	17/05/2018	
240 241	97 98	1	3	2 Ebouh 1 C	1	0 0	0 1 L 0	1		2	2	ZK MN	5	15/05/2018 14/05/2018	17/05/2018 17/05/2018	
242 243	98.1 98.2		14 61	2 C 2 C	1	1	L 0	3				MN MN	5		17/05/2018 17/05/2018	
244 245	98.3	1	4	1 C 2 F 1 F	1	1	L 0	3	7	3	3	MN MN MN	5	14/05/2018		
246 247 248	99.1 99.2 99.3	2 2 2 2	10 48 9	1 F 1 F	1	1 1	0	3				MN MN	5		17/05/2018 17/05/2018 17/05/2018	
249 250	100	1	3 20	1 B 1 B	1	1	0	3		2	2	MN		14/05/2018		
251 252	100.1 100.2 101		60 2	1 B 2 F Bis		1 1	0	3	4	0		MN MN	5		17/05/2018	
253 254	101.1 101.2	2	34 37	2 F Bis 1 F Bis	1	1	0	3				MN MN	5		17/05/2018 17/05/2018	
255 256 257	101.3 102	1	12 2	2 F Bis 2 F 2 F	1	1 1	L 0	3	7	3	3	MN MN		11/05/2018		
257 258 259	102.1 102.2 103	2	6 14 0.75	2 F 2 F 1 F Bis		1 1	0	3		4		MN MN MN	5		17/05/2018 17/05/2018 17/05/2018	
259	103	2	0.75	1 F Bis	1	0 0			9	4		MN		10,00/2016	17/05/2018	

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A N	2	263	104.1	2	25	2 D	1 1	1 1	0	2		1	MN	-		17/05/2018	
A A B A B A B A B C <thc< th=""> <thc< th=""> <thc< th=""> <thc< th=""></thc<></thc<></thc<></thc<>		264	104.2		49	2 D		l 1	0	2		2	MN			17/05/2018	1
B B	-	266	105.1	2	8	2 A Bis	1 1	1 1	0	3		-	MN	5		17/05/2018	
66 10<	5	268	106.1	2	47	2 D	1 1	1 1	0	3		4	MN	5		17/05/2018	
	6	270	106.3	2	19	1 D	1 1	1 1	0	3			MN	5		17/05/2018	
8	7	272	107	1	0.67	2 A Bis	1 1	L 0	0	2	4	1	1 MN	5	16/05/2018	17/05/2018	1
9 3	8	274	107.2	2	25	2 A Bis	1 1	1 1	0	2		2	MN	5	14/05/2018	17/05/2018	
10 20<		276	108.1		3	1 B Bis		L 1	0	1			RT			16/05/2018	
11 1 </th <th></th> <th>278</th> <th></th> <th></th> <th></th> <th>2 B Bis</th> <th>-</th> <th></th> <th></th> <th></th> <th></th> <th>1</th> <th>RT</th> <th></th> <th></th> <th></th> <th>0</th>		278				2 B Bis	-					1	RT				0
1 1 <th1< th=""> 1 1 1 1<th></th><th>280</th><th>110.1</th><th>2</th><th></th><th>2 C</th><th></th><th></th><th>0</th><th>1</th><th>6</th><th>2</th><th>RT</th><th>5</th><th>16/05/2018</th><th>17/05/2018 17/05/2018</th><th>1</th></th1<>		280	110.1	2		2 C			0	1	6	2	RT	5	16/05/2018	17/05/2018 17/05/2018	1
12 13 14 15 16 <							-					1		5	16/05/2018	16/05/2018	0
14 15 16 17 16 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 17 18 18 17 18 <		285	114		2	1 A		L 1	0	3	4	2	2 JY		16/05/2018	16/05/2018	1
14 2 3 3 1 3 5 </td <th>13</th> <td>287</td> <td>115</td> <td>1</td> <td>2</td> <td>1 F Bis</td> <td></td> <td>1 1</td> <td>0</td> <td>3</td> <td>4</td> <td>2</td> <td>2 JY</td> <td></td> <td></td> <td>16/05/2018</td> <td>1</td>	13	287	115	1	2	1 F Bis		1 1	0	3	4	2	2 JY			16/05/2018	1
15 <	14	289	116	1	3	2 E Bis	1 1	l 1	0	3	5	3	3 JY			14/05/2018	0
16 16 16 1	15	291	117	1	2	1 F	1 1	ι 0	0	2	4	2	2 JL	5	08/05/2018	10/05/2018	2
17 18 15 1	16	293	118	1	2	1 F	1 1	ι 0	0	2	3	1	1 JL	5	02/05/2018	10/05/2018	
18 2 4 2 5 6 </td <th></th> <td>295</td> <td>119</td> <td>1</td> <td>0.75</td> <td>1 E</td> <td>1 1</td> <td>ι 0</td> <td>0</td> <td>2</td> <td>7</td> <td>3</td> <td>3 JL</td> <td>5</td> <td>02/05/2018</td> <td>10/05/2018</td> <td></td>		295	119	1	0.75	1 E	1 1	ι 0	0	2	7	3	3 JL	5	02/05/2018	10/05/2018	
19 20 <		297	120	1	4	1 A Bis	1 1	1 1	0	3	6	0	0 JL	5	11/05/2018	17/05/2018	6
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34	469 470 471	185 186 187	1	3 3 2	2 Bareko 1 Bareko	1 1	ι c	0	2	No Visit No Visit No Visit			MN IY IY	7	16/05/2018 19/05/2018 15/05/2018	19/05/2018 15/05/2018	
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41	485 486 487	195.2 196 196.1	1	41 4 5	1 A		1 1	. 0	3	6	0	0	RT RT RT	8	09/06/2018	08/06/2018 10/06/2018 10/06/2018	1
42	488 489 490	197 197.1 197.2	1	1 1 28	2 F 2 F	L 1	L 1	. 0	3	5	2		MN MN MN	8	06/06/2018		0
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44	493 494 495	198.2 198.3 198.4	2	4 13 16	2 C		1 1	. 0	3				MN MN MN	8		05/06/2018 05/06/2018 05/06/2018	
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49	504 505	202.1 202.2	2	50 61	2 Ebouh 1 Ebouh	L 1 L 1	L 1	. 0	3				ZK ZK	8		05/06/2018 05/06/2018	
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52	511 512 513	204 204.1 204.2	2	3 12 11	2 Ebouh 1 Ebouh	L 1	L 1	. 0	3		3		ZK ZK	8		07/06/2018	
53	514 515 516	205 205.1 205.2	1	4 10 9	1 Ebouh 1 Ebouh		1 1	. 0	3		0	0		8	05/06/2018	08/06/2018 08/06/2018 08/06/2018	3
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STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies

	Item No	Recommendation
Title and abstract	1	(<i>a</i>) Indicate the study's design with a commonly used term in the title or the abstract
		Page 2
		(b) Provide in the abstract an informative and balanced summary of what was done
		and what was found Page 2
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
		Page 3
Objectives	3	State specific objectives, including any prespecified hypotheses Page 4
Methods		
Study design	4	Present key elements of study design early in the paper Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment,
		exposure, follow-up, and data collection Page 4-7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of
		participants Page 5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect
		modifiers. Give diagnostic criteria, if applicable Page 6-7
Data sources/	8*	For each variable of interest, give sources of data and details of methods of
measurement		assessment (measurement). Describe comparability of assessment methods if there is
		more than one group Page 6-7
Bias	9	Describe any efforts to address potential sources of bias Page 6
Study size	10	Explain how the study size was arrived at Not calculated
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable,
		describe which groupings were chosen and why Page 7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
Page 7		(b) Describe any methods used to examine subgroups and interactions
		(c) Explain how missing data were addressed
		(<i>d</i>) If applicable, describe analytical methods taking account of sampling strategy
		(e) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially
		eligible, examined for eligibility, confirmed eligible, included in the study,
		completing follow-up, and analysed Page 7-8
		(b) Give reasons for non-participation at each stage Figure 1
		(c) Consider use of a flow diagram Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and
		information on exposures and potential confounders Table 1
		(b) Indicate number of participants with missing data for each variable of interest
		Table 1
Outcome data	15*	Report numbers of outcome events or summary measures Tables 1 and 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and
		their precision (eg, 95% confidence interval). Make clear which confounders were
		adjusted for and why they were included Page 9 and Table 2
		(b) Report category boundaries when continuous variables were categorized
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a

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	meaningful time period
17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Page 9
18	Summarise key results with reference to study objectives Page 10
19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Page 11
20	Give a cautious overall interpretation of results considering objectives, limitations multiplicity of analyses, results from similar studies, and other relevant evidence Page 11
21	Discuss the generalisability (external validity) of the study results Page 11-12
22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Page 15
	18 19 20 21

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.