Basic or enhanced clinician training to improve adherence to malaria treatment guidelines: a cluster-randomised trial in two areas of Cameroon

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Summary

Background The scale-up of malaria rapid diagnostic tests (RDTs) is intended to improve case management of fever and targeting of artemisinin-based combination therapy. Habitual presumptive treatment has hampered these intentions, suggesting a need for strategies to support behaviour change. We aimed to assess the introduction of RDTs when packaged with basic or enhanced clinician training interventions in Cameroon.

Methods We did a three-arm, stratified, cluster-randomised trial at 46 public and mission health facilities at two study sites in Cameroon to compare three approaches to malaria diagnosis. Facilities were randomly assigned by a computer program in a 9:19:19 ratio to current practice with microscopy (widely available, used as a control group); RDTs with a basic (1 day) clinician training intervention; or RDTs with an enhanced (3 days) clinician training intervention. Patients (or their carers) and fieldworkers who administered surveys to obtain outcome data were masked to study group assignment. The primary outcome was the proportion of patients treated in accordance with WHO malaria treatment guidelines, which is a composite indicator of whether patients were tested for malaria and given appropriate treatment consistent with the test result. All analyses were by intention to treat. This study is registered at ClinicalTrials.gov, number NCT01350752.

Findings The study took place between June 7 and Dec 14, 2011. The analysis included 681 patients from nine facilities in the control group, 1632 patients from 18 facilities in the basic-training group, and 1669 from 19 facilities in the enhanced-training group. The proportion of patients treated in accordance with malaria guidelines did not improve with either intervention; the adjusted risk ratio (RR) for basic training compared with control was 1·04 (95% CI 0·53–2·07; p=0·90), and for enhanced training compared with control was 1·17 (0·61–2·25; p=0·62). Inappropriate use of antimalarial drugs after a negative test was reduced from 84% (201/239) in the control group to 52% (413/796) in the basic-training group (unadjusted RR 0·63, 0·28–1·43; p=0·25) and to 31% (232/759) in the enhanced-training group (0·29, 0·11–0·77; p=0·02).

Interpretation Enhanced clinician training, designed to translate knowledge into prescribing practice and improve quality of care, has the potential to halve overtreatment in public and mission health facilities in Cameroon. Basic training is unlikely to be sufficient to support the behaviour change required for the introduction of RDTs.

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Introduction

Presumptive treatment of fever as malaria is entrenched in medical practice in malaria-endemic countries. In many African countries, fewer than 20% of suspected malaria cases were confirmed through parasitological testing in 2009.[1] Increased awareness of the overdiagnosis of malaria and concerns about inappropriate treatment of fevers, drug wastage, and the potential for drug resistance have led WHO to recommend universal parasitological confirmation before the use of artemisinin-based combination therapy.[2] Malaria rapid diagnostic tests (RDTs) offer the potential for improved targeting of artemisinin-based combination therapy in settings where microscopy is absent or of uncertain quality.[3–5]

Studies of malaria diagnosis in public health facilities have shown that clinicians rely on clinical judgment over the results of diagnostic tests.[6–9] Challenges faced by clinicians in the diagnostic process include insufficient training in the use of tests,[10] a distrust of negative test results,[11–13] little confidence or resources to treat alternative causes of fever,[10,12] and the perception of patient demand for antimalarial drugs.[14,15] These challenges seem to persist even when highly sensitive and specific RDTs are used[12] and when the evidence suggests that adhering to RDT results does not have a negative effect on health outcomes.[16] Interventions are urgently needed to address such problems in routine health-care settings.

Few studies have assessed interventions intended to change clinician practice when introducing RDTs, and

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those that have investigated such interventions have produced mixed results, have often used weak study designs, and have provided little information about the interventions used.[17] Policy makers therefore remain uncertain about the types of intervention needed and about which interventions can be implemented within a realistic budget. This study, Research on the Economics of Artemisinin-based Combination Therapy (REACT), was done in two phases and was undertaken to identify interventions that could be adopted by the National Malaria Control Programme to support the distribution of RDTs in Cameroon. In the first phase,[18] formative research showed that microscopy was available at 90% of public health facilities and all mission and private health facilities, and that 35% of patients at public and 44% at mission facilities were tested. Of patients tested during their consultation, 78% of those who had a positive test result were prescribed or received an antimalarial drug (52% artemisinin-based combination therapy), but so were 82% of those who had a negative test result (56% artemisinin-based combination therapy).[18] We therefore recognised a need for changes in clinician knowledge, skills, and mindset to make test-driven diagnoses the norm in this setting.[9,18] The second phase, the results of which are reported here, was a stratified cluster-randomised trial done in a real-world setting to compare the introduction of RDTs in two intervention packages (involving different content and modes of clinician training) to routine care where microscopy is widely available. The overall aim of the study was assess how to improve the targeted use of antimalarial treatment and to optimise the implementation of malaria treatment guidelines.[2]

Methods

Study setting and population

We did a stratified, cluster-randomised trial at 46 public and mission health facilities (clusters) in two study sites (strata) in Cameroon (Yaoundé in the Centre region and Bamenda in the Northwest region). Facilities were eligible for inclusion if they were not included in the Government's pilot rollout of RDTs,[19] did not offer specialist services, received more than four febrile patients per day on average, and were more than 2 km (1 km in Yaoundé) away from another facility. All patients (or their carers) who attended the health facilities between Oct 3 and Dec 14, 2011, were approached on exit for consent to participate in the study and screened for their eligibility. Patients were eligible for inclusion in the exit survey if they reported seeking treatment for fever or suspected malaria, but were excluded if they were pregnant, younger than 6 months, or had signs of severe malaria. Individuals were also excluded if the patient was not present (when a carer was the respondent). Medical doctors, nurses, laboratory technicians, and pharmacy attendants were eligible for the clinician training, and all clinicians responsible for the diagnosis and treatment of malaria were eligible for participation in the assessment of provider knowledge. The nature and purpose of the trial was explained to the participants, all of whom provided written informed consent (consent for child participants was obtained from parents or carers).

Ethics approval was obtained from the London School of Hygiene & Tropical Medicine (number 5885) and the Cameroon National Ethics Committee (number 030/CNE/DNM/09). Administrative clearance was obtained from the Cameroon Ministry of Public Health (number D30-343/AAR/MINSANTE/SG/DROS/CRC/JA). An independent data safety monitoring board monitored the trial and approved the analysis plan.

Randomisation and masking

Within each study site, facilities were randomly selected from those that met the eligibility criteria and had agreed to participate in the study, and were randomly allocated in a 9:19:19 ratio to the control, basic-training intervention, or enhanced-training intervention groups by a process of constrained or restricted randomisation (to improve the balance across the study groups).[20] The study statistician (BC), who had no involvement in the delivery or assessment of the interventions, did the random assignment using a program written in R statistical software version 2.13.0 (R Foundation for Statistical Computing, Vienna, Austria). Patients (or their carers) and fieldworkers who administered the surveys were masked to study group assignment.

Procedures

Clinicians in the control facilities did not receive RDTs or training as part of the study. Facilities in both intervention groups were supplied with 100 RDTs (SD Bioline Malaria Ag Pf/Pan, Standard Diagnostics, Yongin, South Korea) each month without charge. Facilities could charge patients for the use of RDTs, but, in line with national policy, facilities were asked not to charge for their use in children younger than 5 years, and 100 CFA francs (US$0·20) was the recommended price per test for other patients. The availability of artemisinin-based combination therapy was not controlled.

The training interventions were designed to be suitable for implementation on a large scale. Clinicians working at facilities assigned to the basic-training intervention group were invited to a 1-day training course with three separate modules. These modules covered malaria diagnosis, RDTs, and malaria treatment. Together these modules explained to participants that all febrile patients should be tested for malaria using microscopy or an RDT, described the procedures for using an RDT, and explained that confirmed cases of uncomplicated malaria should be treated with artemisinin-based combination therapy, whereas patients with a negative malaria test should not be given antimalarial drugs. The training also included advice about other causes of febrile illness. The training was

provided by representatives of the National Malaria Control Programme and members of the research team who had been trained to deliver the material. Information was disseminated through lectures, and a practical session was run to show participants how to use an RDT.

Clinicians working at facilities in the enhanced-training intervention group received 3 days of training. The first day was identical to that attended by those in the basic-training group, and the remainder of the course covered three additional modules targeting improvements in quality of care. These modules covered adapting to change, professionalism, and effective communication. The module on adapting to change sought to provide clinicians with the opportunity to reflect and discuss the WHO malaria treatment guidelines[2] and to learn from others. It included testimonials about the use of RDTs, and participants reflected on and discussed recommendations in the malaria guidelines.[2] As well as discussions in small groups, the module included a card game for four to six players designed to reinforce the treatment algorithm.

In the professionalism module, clinicians were asked to identify and agree on the values and behaviours that are important when providing care. The module included an exercise in which participants considered real-life scenarios that often interrupt the process of care and were encouraged to develop strategies for managing these situations. The final module focused on improving the clinicians' skills in communicating with patients. It began by reflecting on what patients think about malaria and its treatment. The module also looked at different ways of managing patients' expectations and allowed participants to develop skills and techniques for explaining to patients why they should be tested for malaria and for dealing with the situation in which the test is negative and an antimalarial should not be prescribed. Participants developed and acted out dramas to help them to understand the consequences for patients of not being prescribed an antimalarial drug and the alternative courses of action that could be pursued. These additional modules were designed to reinforce material contained in the malaria treatment guidelines and to address challenges brought by RDTs for the interactions between health workers and patients.[9,18]

In both intervention groups, participants received copies of training materials and job aids (including posters and table-top flip charts) and were strongly encouraged to train other clinicians at their facilities. We used this form of in-facility cascade training because it seemed to be the most feasible approach for this resource-constrained setting. The training materials used are available from the ACT Consortium website.

Data were collected on the process of implementing the interventions: the research team kept records of RDTs supplied to each facility; clinician satisfaction and understanding of training materials was assessed by use of a structured questionnaire at the start and end of the training workshops; and the training facilitators completed an assessment form recording details of the running of the workshops.

Outcomes

The primary outcome was the proportion of patients attending study facilities that reported a fever or suspected malaria and received treatment in accordance with the WHO malaria treatment guidelines.[2] This outcome is a composite measure that requires febrile patients to be tested for malaria (with either microscopy or an RDT), patients with a positive malaria test result to be given artemisinin-based combination therapy, and patients with a negative malaria test result not to receive an antimalarial drug.

The primary outcome was assessed through an interviewer-administered patient exit survey to all eligible and consenting patients (or carers) exiting the study facilities. The survey started 3 months after the interventions were implemented and ran for 3 months. The exit survey asked about the patient's previous treatment seeking, whether the patient was tested, what treatment was prescribed and received, and whether the patient was satisfied with the visit (with options ranging from completely satisfied to not at all satisfied).

Clinicians were asked to complete a register of all malaria tests done by microscopy or RDTs to supplement the exit survey, since patients might not always know whether they were tested for malaria or the result of the malaria test. The register data included facility code, date, patient name, age, sex, type of test done (microscopy or RDT), test result, and the name of the health worker who did the test. A fieldworker collected the register at the end of every week and combined this information with the exit survey results. A subsample of patients (roughly 5%) was independently tested by the research team to determine the degree of consistency between the test results reported by the patients, clinicians, and research team. A facility audit was done once the exit survey was complete to collect details about the health facility (such as type of facility, how long it had been in operation, and the average number of patients treated per day), available resources (such as number and type of staff, testing equipment, and drugs), and management procedures (such as stocking and procurement). Fieldworkers obtained these data by interviewing the head of the facility with a structured questionnaire.

On the basis of our formative research,[18] we assumed that the proportion of patients treated in accordance with malaria treatment guidelines (the primary outcome) would be 15% in the control group and that the coefficient of variation between clusters within each stratum would be 0·25. On the basis of these assumptions, we estimated that a sample size of nine facilities per group with 100 patients per facility would be needed (with allowance for facility withdrawals) to provide 80% power at the 5% significance level to detect a 15 percentage point increase in the primary outcome (ie, increasing the

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proportion to at least 30%) in either of the intervention groups.[19] To test whether the basic training was as effective as the enhanced training, we estimated that a sample size of 19 clusters per group would have 80% power to show that the basic intervention is non-inferior (with a margin of 10%) to the enhanced intervention at the 5% significance level (two-sided). Thus, the number needed for the non-inferiority comparison was greater, and the final sample size was set at nine for the control group and 19 for each intervention groups.[20]

All clinicians responsible for diagnosis and treatment of suspected cases of malaria were asked to take part in a clinician survey. This survey was done after completion of the patient exit survey and measured changes in secondary outcomes between study groups including changes in clinicians' knowledge and preferences for treating patients presenting with symptoms of uncomplicated malaria. The assessment of clinicians' knowledge included a mean score for how to use an RDT, which was derived from the correct identification of 11 steps required to do the test. The logic model in figure 1 shows the expected effect of the provider interventions on primary and secondary outcomes.

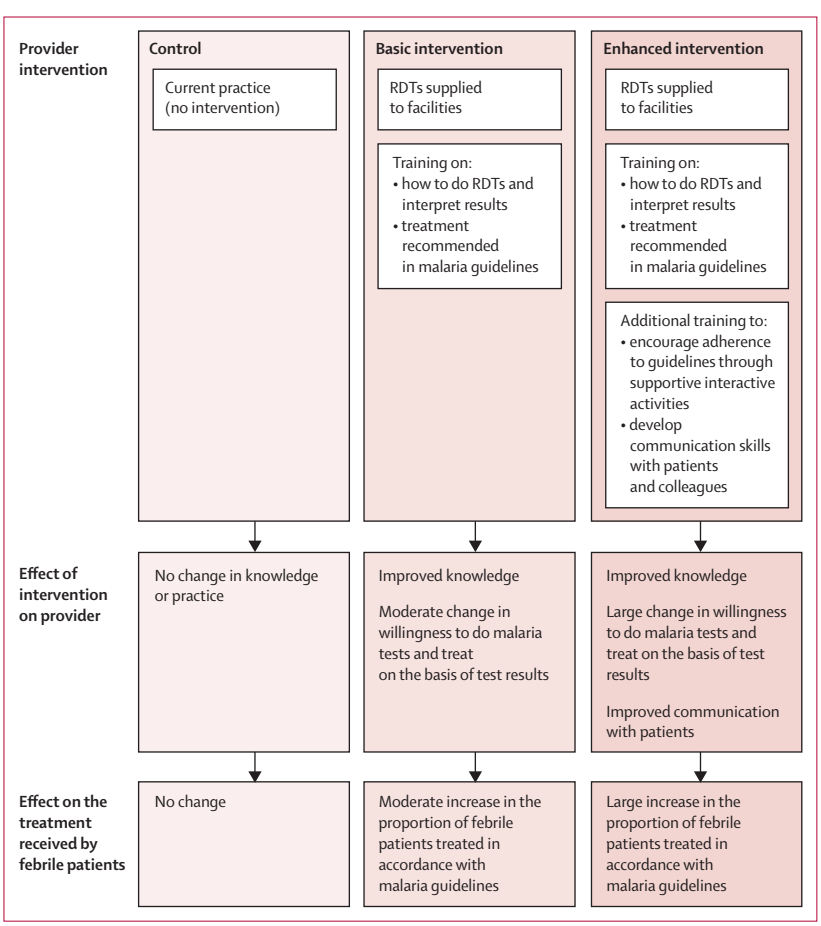

Figure 1: **Logic model for the effect of provider interventions on treatment received by patients**
RDTs=rapid diagnostic tests. Reproduced from reference 20.

Further information about the design of the trial and the interventions is reported in the study protocol.[20]

Statistical analysis

All data were double-entered in Microsoft Access 2007 (Microsoft, Redmond, WA, USA), verified with the data compare utility in Epi Info 2000 (Centers for Disease Control and Prevention, Atlanta, GA, USA), and analysed with Stata version 12.0 (Stata Corporation, College Station, TX, USA). All analyses were by intention to treat. We used methods suitable for stratified, cluster-randomised trials with fewer than 20 clusters per group[21] to assess the effect of each intervention compared with control. Within each stratum, we calculated the risk ratio (RR) from the mean risks across facilities in each intervention group. We calculated an overall estimate of the RR as the geometric weighted average of the stratum-specific RRs, with the weights inversely proportional to the stratum-specific variances. We calculated 95% CIs taking into account the observed between-cluster variation[21] and did formal hypothesis testing by use of a stratified *t* test on the logarithm of the RR.

We adjusted for covariates by fitting a logistic regression model to data for individual patients, including terms for stratum and the covariates of interest, but excluding the intervention effect. We estimated ratio-residuals for each facility by comparing expected and observed values, and we applied the same methods for estimating the RRs and 95% CIs and for hypothesis testing as we used in the main analysis, but with the residuals replacing facility-specific risks. We assessed non-inferiority between the two intervention groups using the same methods used for the main analysis to calculate an overall estimate of the risk difference and a corresponding one-sided 95% CI.

The trial is registered with ClinicalTrials.gov, number NCT01350752.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The study took place between June 7 and Dec 14, 2011. 122 facilities were assessed for eligibility (50 in Yaoundé and 72 in Bamenda); after exclusions, 46 facilities were included in the analyses (24 in Yaoundé and 22 in Bamenda), with nine randomly allocated to the control group, 18 to the basic-training intervention, and 19 to the enhanced-training intervention (figure 2).

The basic and enhanced training workshops were successfully delivered across both study sites, with all 37 intervention facilities represented and the

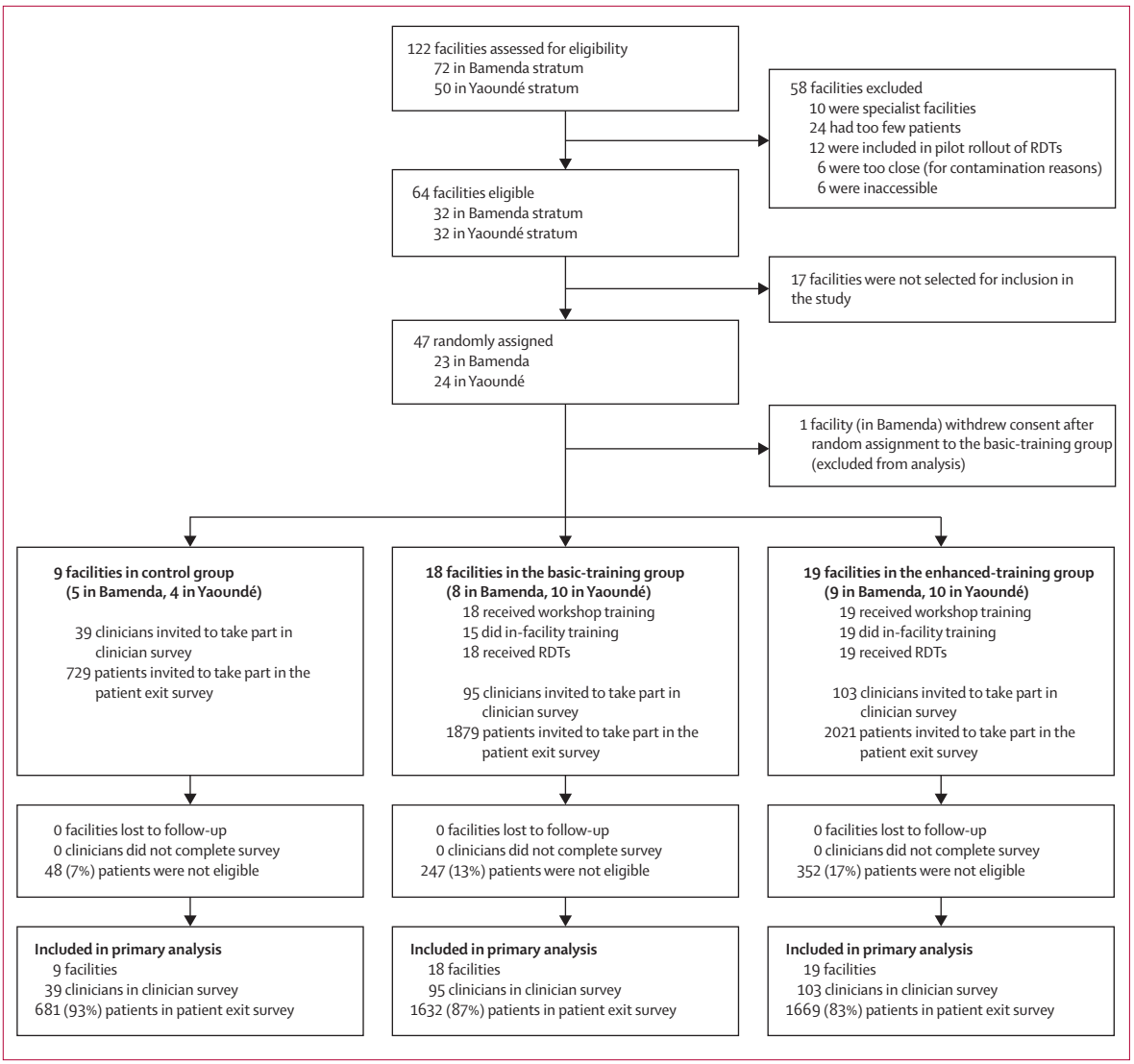

Figure 2: **Study profile**
Flow of facilities (clusters), clinicians, and patients through the study.

training materials delivered as planned. Participant satisfaction was high in both intervention groups, with more than three-quarters of participants (77% [37/48] in the basic-training group and 83% [40/48] in the enhanced-training group) strongly agreeing that they were satisfied with the training (as defined by knowledge gained and the relevance and acceptability of the material). Seven of eight facilitators responsible for delivering the training also strongly agreed that the learning objectives for each module had been achieved successfully. Three facilities in Yaoundé assigned to the basic-training intervention did not do any in-facility cascade training for clinicians who did not attend the workshops (figure 2).

Each month 100 RDTs were supplied to all facilities in the intervention groups, from the end of the training until all assessments were complete (6 months). Despite requests not to charge more than 100 CFA francs (US$0·20) per test, most facilities charged substantially more, with a mean charge of 611 CFA francs ($1·28) per test in facilities in the basic-training group and 997 CFA francs ($2·09) in the enhanced-training group. Facilities were supplied with artemisinin-based combination therapy by the Government or mission authorities, and availability was reasonably good; four public facilities reported stock-outs in the 4 weeks before the facility audit, and eight reported problems obtaining stock in the previous year.

Characteristics of the facilities and patients were generally similar across the groups (tables 1, 2), but with some exceptions: there were disproportionately more public than mission facilities in the control group;

	Control (n=9)	Basic training (n=18)	Enhanced training (n=19)
Stratum			
Bamenda	5 (56%)	8 (44%)	9 (47%)
Yaoundé	4 (44%)	10 (56%)	10 (53%)
Type of facility			
Public district hospital	1 (11%)	6 (33%)	4 (21%)
Public health centre	7 (78%)	5 (28%)	6 (32%)
Mission hospital	0 (0%)	0 (0%)	1 (5%)
Mission health centre	1 (11%)	7 (39%)	8 (42%)
Time established*			
≤5 years (at time of facility audit)	1 (11%)	2 (11%)	2 (11%)
>5 years (at time of facility audit)	8 (89%)	15 (83%)	15 (79%)
Unknown	0	1 (6%)	2 (11%)
Median number of patients per day (IQR)	8 (5–10)	20 (15–30)	30 (10–75)
Median number of clinicians (range)			
Who regularly work at the facility	17 (4–32)	16 (4–35)	11 (4–61)
Who are involved in the treatment of patients with malaria†	8 (2–14)	8 (4–18)	9 (4–20)
Types of clinician†			
Doctor	4 (44%)	9 (50%)	9 (47%)
Nurse or midwife	8 (89%)	16 (89%)	14 (74%)
Nurse assistant or midwife assistant	5 (56%)	11 (61%)	12 (63%)
Laboratory technician or assistant	8 (89%)	16 (89%)	19 (100%)
Pharmacist	2 (22%)	1 (6%)	3 (16%)
Pharmacy technician or assistant	7 (78%)	15 (83%)	14 (74%)
Services available			
Weighing scale	8 (89%)	18 (100%)	18 (95%)
Functioning thermometer	8 (89%)	17 (94%)	15 (79%)
Functioning microscope‡	9 (100%)	18 (100%)	18 (95%)
Malaria microscopy testing‡	9 (100%)	18 (100%)	19 (100%)
RDT, ACT, and antibiotic availability			
ACTs currently in stock	8 (89%)	18 (100%)	19 (100%)
Stock-outs of ACTs in past 4 weeks	1 (11%)	2 (11%)	1 (5%)
ACT supply problems in past year	2 (22%)	3 (17%)	3 (17%)
RDTs currently in stock§	1 (11%)¶	8 (47%)‖	13 (72%)‖
Stock-outs of RDTs in past 4 weeks§	1 (11%)¶	10 (59%)‖	10 (56%)‖
Antibiotics currently in stock	8 (89%)	16 (89%)	18 (95%)

Data are number of facilities (%), unless otherwise indicated. RDT=rapid diagnostic test. ACT=artemisinin-based combination therapy. *All facilities had been established for a minimum of 3 years. †Clinicians who diagnose, prescribe, or dispense malaria treatment at the facility. ‡One facility in the enhanced-training group noted that it provided microscopy testing, but it did not have a functioning microscope ; all facilities that offered malaria microscopy testing had at least one laboratory technician or assistant who regularly worked at the facility, apart from four facilities in the enhanced-training group for which this information is unavailable. §The facility audit was done after the exit survey was complete. ¶One facility in the control group received RDTs as a donation and not as part of the intervention; they did not receive any training associated with the use of RDTs. ‖Information was unavailable for one facility in the basic-training group and one facility in the enhanced-training group (these facilities were excluded from the percentage calculations).

Table 1: **Characteristics of facilities (clusters), by study group**

intervention facilities treated a larger number of patients per day; and patients seeking treatment at control facilities were of a higher socioeconomic status than those at intervention facilities. Concordance between RDT reporting in registers and exit-poll information was high (sensitivity 96%, specificity 94%, observed agreement 95%, κ=0·89).

Neither training intervention had a significant effect on the proportion of febrile patients treated in accordance with malaria treatment guidelines (table 3). The proportion of patients tested for malaria was high across all groups. Compared with the control group, the proportion of patients with a negative test result who were prescribed or received an antimalarial drug was significantly reduced in the enhanced-training group and non-significantly reduced in the basic-training group (table 3). The proportion of patients with a positive test result who were prescribed or received

artemisinin-based combination therapy was similar across the study groups at 72–75% (table 3); most of the remaining patients with a positive test result received either another antimalarial treatment or an antibiotic (figure 3). The proportion of febrile patients who were prescribed or received an antimalarial receiving artemisinin-based combination therapy was similar across the study groups: 508 (85%) of 598 in the control group, 790 (79%) of 997 in the basic-training group, and 694 (79%) of 873 in the enhanced-training group; the unadjusted RR was 0·91 (95% CI 0·74–1·13; p=0.38) for basic training compared with control and 0·81 (0·51–1·28; p=0.35) for enhanced training compared with control.

The study was powered to assess non-inferiority between the two intervention groups, and the crude risk difference between the two groups was 0·15 (90% CI –0·29 to 0·60); since the difference and the upper bound of the CI is more than 10%, non-inferiority is not shown in the analysis.

	Control (n=681)	Basic training (n=1632)	Enhanced training (n=1669)
Median number of patients per facility (range)	80 (28–101)	100 (49–102)	98 (17–114)
Sex			
Male	312 (46%)	735 (45%)	733 (44%)
Female	369 (54%)	897 (55%)	934 (56%)
Missing data	0	0	2 (<1%)
Age			
<5 years	236 (35%)	600 (37%)	610 (37%)
5–19 years	194 (28%)	370 (23%)	368 (22%)
20–40 years	131 (19%)	431 (26%)	438 (26%)
≥40 years	120 (18%)	231 (14%)	253 (15%)
Main activity of patient			
Paid work or self-employed	141 (21%)	294 (18%)	352 (21%)
Domestic work	55 (8%)	159 (10%)	146 (9%)
Looking for work	7 (1%)	27 (2%)	37 (2%)
At school, college, or university	293 (43%)	687 (42%)	606 (36%)
At leisure	22 (3%)	35 (2%)	51 (3%)
Child and does not go to school	158 (%)	401 (25%)	438 (26%)
Other or missing data	5 (1%)	29 (2%)	39 (2%)
Education of respondent			
None	49 (7%)	140 (9%)	141 (8%)
Primary	206 (30%)	426 (26%)	409 (25%)
Secondary	314 (46%)	705 (43%)	731 (44%)
Tertiary	104 (15%)	338 (21%)	371 (22%)
Missing data	8 (1%)	23 (1%)	17 (1%)
Wealth index*			
Poorest	160 (23%)	553 (34%)	548 (33%)
Less poor	232 (34%)	537 (33%)	492 (29%)
Least poor	263 (39%)	460 (28%)	537 (32%)
Missing data	26 (4%)	82 (5%)	92 (6%)
(Continued from previous page)			
Median days of illness (range)	3 (0–14)	3 (0–30)	3 (0–60)
Seeking treatment for first time			
No†	181 (27%)	656 (40%)	582 (35%)
Yes	492 (72%)	962 (59%)	1071 (64%)
Missing data	8 (1%)	14 (1%)	16 (1%)
Previous treatment seeking‡			
Public facility	81 (45%)	133 (20%)	122 (21%)
Mission facility	16 (9%)	82 (13%)	39 (7%)
Private facility	55 (30%)	263 (40%)	244 (42%)
Other§	24 (13%)	164 (25%)	156 (27%)
Missing data	5 (3%)	14 (2%)	21 (4%)

(Table 2 continues on next page)

	Control (n=681)	Basic training (n=1632)	Enhanced training (n=1669)
(Continued from previous page)			
Previous treatment received¶			
Had RDT or microscopy‡			
Yes	67 (37%)	92 (14%)	127 (22%)
No	99 (55%)	536 (82%)	431 (74%)
Missing data	15 (89%)	28 (4%)	24 (4%)
Received ACT‡			
Yes	46 (25%)	152 (23%)	148 (25%)
No	116 (64%)	474 (72%)	387 (66%)
Missing data	19 (10%)	30 (5%)	47 (8%)
Received appropriate treatment||			
Yes	23 (34%)	47 (51%)	75 (59%)
No	18 (27%)	29 (32%)	19 b(15%)
Missing data	26 (39%)	16 (17%)	33 (26%)

Data are n (%), unless otherwise indicated. RDT=rapid diagnostic test. ACT=artemisinin-based combination therapy. *Generated through principal component analysis and based on ownership of household possessions (eg, electricity, radio, mobile telephone, generator, bicycle, and car), access to utilities (toilet type and source of drinking water), and housing characteristics (floor type, fuel, people per sleeping room), in line with the Demographic and Health Survey wealth index[22] and the technique described by Vyas and colleagues;[23] tertiles were used for tabular analysis of the wealth index. †For patients who had previously sought treatment for this illness episode across all groups, 562 (40%) of 1419 had sought treatment once before, 503 (35%) twice before, and 211 (15%) three or more times before (data were missing for 143 [10%]). ‡Patients not seeking treatment for the first time used as totals for percentage calculations. §Other places patients sought treatment include non-specified hospitals, at home, from friends, and from traditional healers. ¶Treatment received at the last place the patient previously sought treatment for this illness, as reported by the patient. ||Appropriate treatment is defined as receiving an ACT if RDT or microscopy was positive for malaria, and not receiving an antimalarial drug if RDT or microscopy was negative for malaria; patients who had RDT or microscopy used as totals for percentage calculations.

Table 2: **Characteristics of patients who participated in the exit survey, by study group**

A higher proportion of patients tested by microscopy had positive test results than those tested by RDT. For microscopy, 53% of cases in the control group, 40% in the basic-training group, and 45% in the enhanced-training group had positive test results. For RDT, 53% of cases in the control group, 23% in the basic-training group, and 31% in the enhanced-training group had positive test results.

With the possible exception of how to use an RDT, there were no significant differences between study groups in clinicians' responses to knowledge questions and treatment preferences (table 4). This finding was consistent with the treatment of such patients during the study. With respect to patient satisfaction, 616 (90%) of 681 febrile patients in the control group, 1393 (85%) of 1632 in the basic-training group, and 1478 (89%) of 1669 in the enhanced-training group were satisfied with the care received. Thus, no significant differences from control were seen in either the basic-training group (unadjusted RR 1·01, 95% CI 0·95–1·07; p=0·70) or the enhanced-training group (0·99, 0·93–1·04; p=0·59).

Discussion

Although the two training interventions did not lead to a significant increase in the proportion of patients treated in accordance with malaria treatment guidelines (the primary outcome), we did note a substantial and significant reduction in the unnecessary use of antimalarial drugs in patients with a negative test result in the enhanced-training group compared with control. Use of this intervention could potentially halve overtreatment in public and mission health facilities in Cameroon. However, further studies are necessary to substantiate this finding.

We also noted improvements in two other key indicators compared with our findings from the formative research in 2009.[18] First, nearly 80% of febrile patients were tested for malaria across all study groups, representing a substantial improvement from the 35–44% noted in 2009. Second, about 75% of patients who tested positive for malaria across all study groups were prescribed or received artemisinin-based combination therapy, compared with 59% during the formative research period. Both of these practices had been targeted by an extensive malaria communication campaign.

Changing established clinical behaviours can be difficult.[24,25] We undertook this study in response to calls for more evidence and for theory-driven approaches to intervention design.[26,27] We compared a conventional, knowledge-based and skills-oriented, didactic training approach (the basic-training intervention) with a mindset-oriented, interactive training approach (the enhanced-training intervention). The interventions were designed in conjunction with the National Malaria Control Programme and the enhanced-training intervention was carefully designed and piloted to tackle issues raised by clinicians in their communities of

	Number of clusters	Number of patients (n/N [%])	Stratum-specific RR (95% CI)	Unadjusted RR (95% CI)*	Adjusted RR (95% CI)†	p value	k
Treatment in accordance with malaria treatment guidelines (composite outcome)							
Control	9	246/659 (37%)	..	1·00	..	..	..
Bamenda	5	86/388 (22%)	1·00	..	..	..	..
Yaoundé	4	160/271 (59%)	1·00	..	..	..	..
Basic training	18	670/1576 (42%)	..	1·18 (0·56–2·49)	1·04 (0·53–2·07)	0·90	0·15
Bamenda	8	265/678 (39%)	2·01 (1·27–3·16)	..	..	..	..
Yaoundé	10	405/898 (45%)	0·66 (0·41–1·06)	..	..	..	..
Enhanced training	19	890/1613 (55%)	..	1·76 (0·83–3·70)	1·17 (0·61–2·25)	0·62	0·16
Bamenda	9	427/754 (57%)	3·61 (2·33–5·59)	..	..	..	..
Yaoundé	10	463/859 (54%)	0·78 (0·49–1·24)	..	..	..	..
Febrile patients tested for malaria							
Control	9	539/681 (79%)	..	1·00	..	..	..
Bamenda	5	313/400 (78%)	1·00	..	..	..	..
Yaoundé	4	226/281 (80%)	1·00	..	..	..	..
Basic training	18	1250/1632 (77%)	..	0·97 (0·76–1·23)	0·95 (0·76–1·18)	0·62	0·05
Bamenda	8	494/699 (71%)	0·92 (0·79–1·07)	..	..	..	..
Yaoundé	10	756/933 (81%)	1·02 (0·88–1·19)	..	..	..	..
Enhanced training	19	1309/1665 (79%)	..	1·01 (0·74–1·37)	0·96 (0·72–1·28)	0·78	0·06
Bamenda	9	617/776 (80%)	1·08 (0·90–1·30)	..	..	..	..
Yaoundé	10	692/889 (78%)	0·94 (0·77–1·13)	..	..	..	..
Patients with positive test results received ACT							
Control	8	208/278 (75%)	..	1·00	..	..	..
Bamenda	4	56/75 (75%)	1·00	..	..	..	..
Yaoundé	4	152/203 (75%)	1·00	..	..	..	..
Basic training	17	287/398 (72%)	..	1·01 (0·67–1·52)	1·09 (0·76–1·56)	0·61	0·06
Bamenda	7	33/47 (70%)	1·14 (0·86–1·51)	..	..	..	..
Yaoundé	10	254/351 (72%)	0·91 (0·70–1·17)	..	..	..	..
Enhanced training	19	363/498 (73%)	..	0·87 (0·52–1·44)	0·89 (0·55–1·44)	0·62	0·11
Bamenda	9	117/147 (80%)	0·85 (0·71–1·01)	..	..	..	..
Yaoundé	10	246/351 (70%)	0·88 (0·74–1·05)	..	..	..	..
Patients with negative test results received an antimalarial drug‡							
Control	8	201/239 (84%)	..	1·00	..	..	..
Bamenda	5	196/226 (87%)	1·00	..	..	..	..
Yaoundé	3	5/13 (38%)	1·00	..	..	..	..
Basic training	18	413/796 (52%)	..	0·63 (0·28–1·43)	..	0·25	0·15
Bamenda	8	194/426 (46%)	0·43 (0·26–0·70)		..	..	..
Yaoundé	10	219/370 (59%)	1·04 (0·59–1·86)	..	..	..	..
Enhanced training	19	232/759 (31%)	..	0·29 (0·11–0·77)	..	0·02	0·20
Bamenda	9	138/448 (31%)	0·14 (0·08–0·26)		..	..	..
Yaoundé	10	94/311 (30%)	0·74 (0·37–1·48)	..	..	..	..

RR=risk ratio. ACT=artemisinin-based combination therapy. *Crude analysis adjusted for stratum only, based on geometric means of cluster summaries; overall *F*-test of the null hypothesis that there are no differences between any of the treatment arms provides p value of 0·08. †Adjusted for the following facility and patient characteristics: stratum; facility type; stock-outs of ACTs in past 4 weeks; average number of patients per day; patients' sex, age, job or main activity, and socioeconomic status; whether patient had previously sought treatment for this illness; and whether they asked for a blood test at the facility. ‡The sample size in some clusters within the strata was too small to do an adjusted analysis for this outcome.

Table 3: **Unadjusted and adjusted effects of the training interventions on treatment in accordance with malaria guidelines, compared with control**

practice and to use best-practice methods for adult learning.

In making choices about our interventions and methods for assessment, we sought to investigate the effectiveness of the interventions in a real-world setting, rather than their efficacy in a highly controlled environment. For example, RDTs were supplied on a monthly basis and the quantity set in consultation with the National Malaria Control Programme to represent a realistic disbursement schedule. Despite this forward planning, stock-outs of RDTs in the past 4 weeks were still reported across all study groups during the

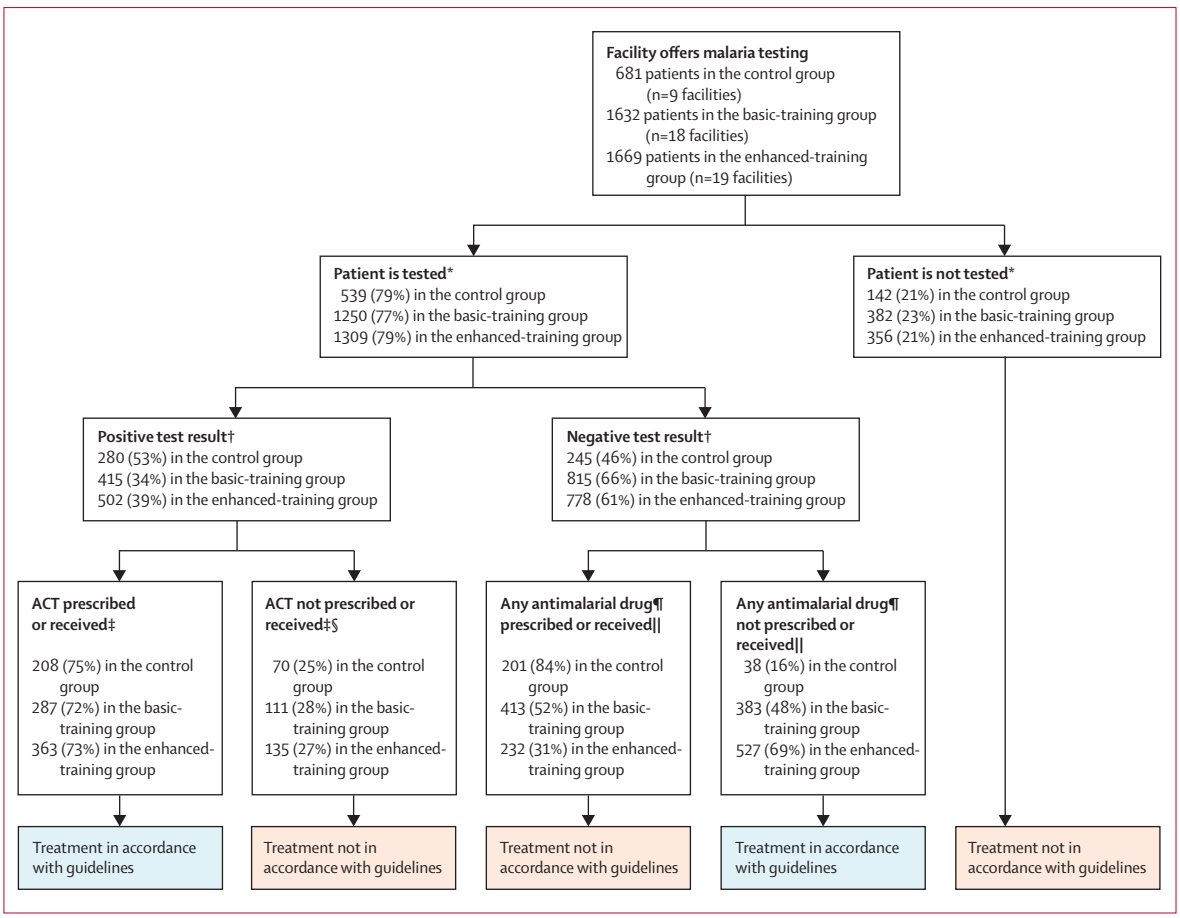

Figure 3: **Flow chart for the definition of the primary outcome**
Missing data were excluded from percentage calculations. ACT=artemisinin-based combination therapy. *Testing could not be established from malaria registers for eight (1%) patients in the control group, 69 (4%) in the basic-training group, and 83 (5%) in the enhanced-training group (in these cases testing was established as reported by the patient); whether or not a patient was tested was not known for four of 1669 (<1%) patients in the enhanced-training group (treated as missing data). †Among patients who were tested, test result could not be established from malaria registers for 18 (3%) in the control group, 89 (7%) in the basic-training group, and 79 (6%) in the enhanced-training group; of these, 14 (3%) in the control group, 20 (2%) in the basic-training group, and 29 (2%) in the enhanced-training group did not have a test result reported by the patient or had an invalid result (treated as missing data). ‡Among patients with a positive test result, whether a treatment was prescribed or received was not known for two (1%) in the control group, 17 (4%) in the basic-training group, and four (1%) in the enhanced-training group (treated as missing data). §Among patients with a positive test result who were not prescribed or receiving ACT, 58 (83%) in the control group, 69 (62%) in the basic-training group, and 89 (66%) in the enhanced-training group were prescribed or received an antimalarial drug; of those not prescribed or receiving any antimalarial drug (including ACT), six (50%) in the control group, 19 (45%) in the basic-training group, and 17 (37%) in the enhanced-training group were prescribed or received either paracetamol or an antibiotic, with the remainder being prescribed or receiving either vitamins, iron, or nothing. ¶Any antimalarial drug includes ACT. ||Among patients with a negative test result, whether a treatment was prescribed or received was not known for six (2%) in the control group, 19 (2%) in the basic-training group, and 19 (2%) in the enhanced-training group (treated as missing data).

assessment. Moreover, cascade training was used to limit the direct costs of the interventions, making them more affordable for large-scale implementation.

The independent verification of malaria test results lends support to the internal validity of outcomes that relied on patients' recall and clinicians' ability to do the diagnostic tests and accurately interpret their results. However, two methodological constraints limit the external application of the findings from this study. First, many of the clinicians surveyed did not attend the training workshops and therefore the knowledge and practice of those treating patients in whom the outcomes were measured was most likely informed by in-facility training, or no training. This issue limits our ability to estimate the effect of attending workshops compared with participating in in-facility training. Second, the assessment was done 3 months after the workshops took place, and we do not know the long-term effects of intervention on clinicians' practice.

The Government of Cameroon, along with those of other malaria-endemic countries, is preparing for the national scale-up of RDTs. Our results suggest that supporting interventions should be employed alongside RDT rollout if presumptive practices are to be changed (panel). This study, the first of its kind in Cameroon, provides timely evidence about the effects of different types of intervention,

	Control (n=39)	Basic training (n=95)	Enhanced training (n=103)	Crude RR* (95% CI)	Adjusted RR† (95% CI)	p value
Clinician knowledge						
Fever is a symptom of uncomplicated malaria	38/39 (97%)	89/95 (94%)	99/103 (96%)	..	..	..
Basic training *vs* control	..	..	..	0·93 (0·81–1·08)	0·97 (0·83–1·12)	0·63
Enhanced training *vs* control	..	..	..	0·95 (0·86–1·05)	0·97 (0·87–1·07)	0·53
Febrile patients should be tested for malaria	37/38 (97%)	90/91 (99%)	100/101 (99%)	..	..	..
Basic training *vs* control	..	..	..	1·01 (0·97–1·06)	1·00 (0·95–1·05)	0·91
Enhanced training *vs* control	..	..	..	1·01 (0·97–1·06)	1·00 (0·96–1·04)	0·97
How to use an RDT‡§	4·3 (4·1)	6·2 (3·7)	6·7 (3·5)	..	..	..
Basic training *vs* control	..	..	..	1·95 (0·42–4·32)	..	0·10
Enhanced training *vs* control	..	..	..	2·55 (0·23–4·86)	..	0·03
How to interpret an RDT result‡	11/13 (85%)	56/73 (77%)	53/77 (69%)	..	..	..
Basic training *vs* control	..	..	..	0·86 (0·59–1·26)	..	0·84
Enhanced training *vs* control	..	..	..	0·76 (0·46–1·24)	..	0·83
Patients with a positive test results should receive an ACT	35/38 (92%)	79/87 (91%)	76/91 (83%)	..	..	..
Basic training *vs* control	..	..	..	0·96 (0·85–1·08)	1·01 (0·87–1·17)	0·91
Enhanced training *vs* control	..	..	..	0·89 (0·74–1·07)	1·08 (0·93–1·25)	0·31
Patients with a negative test results should not receive an antimalarial drug	19/35 (54%)	57/83 (69%)	66/95 (69%)	..	..	..
Basic training *vs* control	..	..	..	1·15 (0·86–1·54)	1·06 (0·73–1·54)	0·73
Enhanced training *vs* control	..	..	..	1·26 (0·88–1·79)	1·28 (0·80–2·06)	0·29
First-line treatment as recommended by the Government	21/35 (60%)	60/77 (78%)	67/90 (74%)	..	..	..
Basic training *vs* control	..	..	..	1·25 (0·75–2·11)	0·97 (0·59–1·60)	0·91
Enhanced training *vs* control	..	..	..	1·12 (0·74–1·69)	1·11 (0·73–1·67)	0·61
Clinician treatment preferences						
Believes that using a patient's symptoms to diagnose malaria is reliable	25/39 (64%)	29/94 (31%)	21/102 (21%)	..	..	..
Basic training *vs* control	..	..	..	0·50 (0·30–0·83)	0·72 (0·39–1·33)	0·28
Enhanced training *vs* control	..	..	..	0·33 (0·21–0·53)	0·94 (0·49–2·50)	0·10
Takes history, signs and symptoms, examination, or temperature	33/39 (85%)	70/95 (74%)	71/103 (69%)	..	..	..
Basic training *vs* control	..	..	..	0·83 (0·58–1·19)	0·97 (0·68–1·38)	0·85
Enhanced training *vs* control	..	..	..	0·78 (0·59–1·02)	0·96 (0·74–1·25)	0·76
Uses RDT or microscopy to diagnose malaria	34/39 (87%)	88/95 (93%)	90/102 (88%)	..	..	..
Basic training *vs* control	..	..	..	1·04 (0·91–1·18)	0·99 (0·86–1·13)	0·83
Enhanced training *vs* control	..	..	..	0·95 (0·76–1·19)	0·95 (0·77–1·18)	0·63
Believes that test results are reliable	16/37 (43%)	49/89 (55%)	69/100 (69%)	..	..	..
Basic training *vs* control	..	..	..	1·39 (0·73–2·68)	1·06 (0·57–1·95)	0·85
Enhanced training *vs* control	..	..	..	1·93 (1·22–3·03)	1·22 (0·76–1·95)	0·39
Believes that ACT is the best treatment for malaria in adults	34/37 (92%)	69/88 (78%)	72/95 (76%)	..	..	..
Basic training *vs* control	..	..	..	0·88 (0·71–1·09)	1·01 (0·80–1·28)	0·92
Enhanced training *vs* control	..	..	..	0·73 (0·44–1·21)	0·94 (0·58–1·54)	0·81
Believes that ACT is the best treatment for malaria in children	37/38 (97%)	73/88 (83%)	80/96 (83%)	..	..	..
Basic training *vs* control	..	..	..	0·87 (0·74–1·02)	1·00 (0·87–1·15)	0·98
Enhanced training *vs* control	..	..	..	0·79 (0·58–1·09)	0·96 (0·71–1·30)	0·77
Thinks that it is good to give antimalarial drugs to patients with negative test results	34/39 (87%)	50/91 (55%)	39/101 (39%)	..	..	..
Basic training *vs* control	..	..	..	0·52 (0·34–0·81)	0·89 (0·58–1·37)	0·60
Enhanced training *vs* control	..	..	..	0·33 (0·19–0·56)	0·91 (0·55–1·52)	0·71

Data are n/N (%), unless otherwise indicated. Missing data were excluded from percentage calculations. Clinician knowledge was measured through specific knowledge-based questions in the clinician survey; clinician treatment preferences were based on questions in the clinician survey about what the clinician thinks and would do in specific circumstance. RDT=rapid diagnostic test. ACT=artemisinin-based combination therapy. *Crude analysis adjusted for stratum only; data are risk difference for continuous outcomes. †Adjusted for the following facility and clinician characteristics: stratum, facility type, and clinician sex, education, and type (for some outcomes only stratum and facility type were included because of multicollinearity and perfect prediction of the clinician characteristics). ‡Adjusted analysis could not be done for these outcomes because the the sample sizes were too small to provide robust estimates. §Data are mean (SD); based on a score (out of 11) derived from correct identification of several steps taken in the use of an RDT; only measured in 23 clinicians in the control group, 85 in the basic-training group, and 93 in the enhanced-training group.

Table 4: **Effect of the intervention on clinician knowledge and treatment preferences**

Panel: Research in context

Systematic review

We sought to identify studies that have assessed interventions intended to improve the ability of health workers to diagnose and treat patients with uncomplicated malaria. We systematically searched Medline, Embase, the CABI Global Health database, the International Bibliography of Social Sciences, CAB Abstracts, and the International Network for the Rational Use of Drugs for reports published in English between Jan 1, 1990, and Nov 26, 2009, using a list of truncated synonyms for the search terms "malaria" AND "treatment" AND "intervention" AND "provider". Studies were regarded as eligible irrespective of the type of health provider so long as the effect of the intervention included a malaria-related outcome. Eligibility was restricted to studies that took a comparative approach, using either a before-and-after study design or comparing an intervention with a comparison group. 28 studies (assessing 33 different interventions) met the eligibility criteria. 20 of the interventions focused on provider training and used learning techniques to improve diagnosis and treatment of malaria. Only six provider-training interventions included malaria diagnostic tests. Although the results showed that these interventions led to improvements in the appropriate treatment of malaria, the proportion of patients receiving an antimalarial drug after a negative test result remained fairly high. Recent reviews of interventions designed to improve clinician management of malaria have had similar findings,[16,28] showing that the links between staff training and clinical performance remain mixed and in short supply. A recent systematic review[16] that assessed the introduction of rapid diagnostic tests (RDTs) into diagnostic algorithms for patients with fever showed that health-worker adherence to test results was highly variable—between 0% and 80% of patients with a negative test result received an antimalarial drug. Notably, all the reports included in these reviews[16,28] included little detail of the interventions used, limiting the extent to which these studies can usefully guide policy makers and programme managers in the selection of methods to support a shift in practice towards appropriate use of antimalarial drugs alongside RDTs.

Interpretation

Governments of many malaria-endemic countries are preparing to scale up the use of RDTs nationally. WHO malaria treatment guidelines[2] acknowledge the need for provider training alongside the deployment of RDTs and artemisinin-based combination therapy to address key problems such as the habitual presumptive treatment of malaria. Our study provides timely evidence about the effects of different types of supporting interventions. Our results show that enhanced training, designed to translate knowledge into prescribing practice and improve quality of care, has the potential to substantially improve adherence to negative RDT results, which in Cameroon could halve overtreatment in public and mission health facilities. Basic training is unlikely to be sufficient to support the behaviour change required for the introduction of RDTs.

with potentially substantial effects on the overuse of antimalarial drugs. Specifically, we have shown that an enhanced training programme, designed to translate knowledge into prescribing practice and improve quality of care, has the potential to significantly reduce the unnecessary use of antimalarial drugs in patients who have tested negative for malaria. Basic training that focuses only on how to use RDTs and the content of malaria treatment guidelines is unlikely to bring about the behaviour change needed to support the national rollout of RDTs.

Contributors

WFM and VW conceived the study. VW, WFM, LM-J, CIRC, and BC designed the study. BC led the data analysis. OAA, JNA, and LM-J designed the interventions and managed their implementation. VN, OT, and PO-Z reviewed training materials and supported implementation of the interventions in Yaoundé. DF-A and AN reviewed training materials and supported implementation in Bamenda. VW and WFM prepared the first draft of the report with input from all authors, and all authors contributed to subsequent drafts. All authors approved the final draft of the report.

Declaration of interests

We declare that we have no competing interests.

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