Transactions of the Royal Society of Tropical Medicine and Hygiene Advance Access published August 8, 2014

Trans R Soc Trop Med Hyg
doi:10.1093/trstmh/tru127

ORIGINAL ARTICLE

An assessment of malaria diagnostic capacity and quality in Ghana and the Republic of Benin

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Received 20 March 2014; revised 6 July 2014; accepted 7 July 2014

Background: In malaria–endemic countries, the absence of parasitological confirmation of malaria infection potentially results in overtreatment of non-malaria febrile illness with antimalarial drugs; this may lead to health-care workers (HCW) missing other treatable illness or wastage of resources. This paper presents results from nationally representative assessments of malaria diagnostic accuracy, quality and capacity in Ghana and the Republic of Benin.

Methods: Cross-sectional surveys were conducted in December 2012 among a representative sample of health facilities (n=30 per country), using a modified service provision assessment, followed by HCW observations and interviews. To analyze the data we used χ^2 statistics and logistic regression.

Results: Malaria microscopy and rapid diagnostic test interpretation was accurate most of the time in both countries. Drugs were generally prescribed in line with positive malaria test results (Ghana: 85.4%, 95% CI 72.2–98.7; Benin: 83.6%, 95% CI 68.7–98.4), although some patients with negative malaria test results still received treatment (Ghana: 30.1%, 95% CI 11.1–49.0; Benin: 37.8%, 95% CI 22.6–53.0).

Conclusions: Diagnostics for malaria are often performed adequately and accurately in Ghana and Benin, although diagnostic coverage within facilities remains incomplete and some individuals who test negative for malaria receive antimalarial drugs.

Keywords: Benin, Diagnostic, Ghana, Health facility, Malaria, Rapid assessment

Introduction

The development of sensitive and specific antigen-based rapid diagnostic tests (RDTs) for malaria combined with the scale-up of a new, more expensive drug therapy (artemisinin combination therapies [ACTs]) has led to increasing demand for the scale-up of high-quality parasitological diagnosis in sub-Saharan Africa.[1] The WHO updated its treatment guidelines to call for universal parasitological diagnosis, where available, before treatment of suspected malaria with antimalarial drugs in all age groups.[2]

In sub-Saharan Africa, individuals suspected to have malaria have regularly been treated presumptively, or treated on the basis of clinical signs and symptoms only.[1,3–5] Recent household survey data also indicate generally low rates of diagnostic testing among febrile children in sub-Saharan Africa.[6] In the absence of parasitological confirmation of malaria infection, using microscopy or RDTs, such procedures can lead to overtreatment of non-malarial febrile illness with antimalarial drugs, and increases the potential to miss other treatable and potentially fatal conditions.[7] Furthermore, overtreatment can lead to wastage of resources (e.g., of antimalarial medications) and might contribute to the development resistance to antimalarial drugs.[8–11] In some areas of sub-Saharan Africa, however, and typically at higher-level health systems in urban areas, laboratory capacity does exist. In these locations, parasitological confirmation of infection to support malaria diagnosis is most commonly obtained by routine microscopy of Giemsa-stained thick film blood smears.[12–14]

While high-quality results can be obtained by trained technicians with access to microscopes and supplies, weak infrastructure, under-staffing, poor training and lack of quality assurance and control systems (QA/QC) can often result in poor quality

routine microscopy,[15] and potentially undermine malaria prevention and control strategies. The general lack of reliable routine diagnostics for malaria also contributes to negative outcomes outside of patient care, including poor quality data for the monitoring and evaluation of malaria programs and poor predictability in drug and commodity stock management.[16–18] Widespread unreliability of laboratory diagnostics for malaria may also decrease trust in them on the part of patients and healthcare workers (HCWs) (that is, any person who works directly with patients, rather than in a laboratory or in research); a lack of trust in the results of diagnostics can lead to patients without a parasite infection being treated with antimalarial drugs even in the presence of reliable negative diagnostic test results.[15] In the absence of diagnostic capacity, the resulting overdiagnosis of malaria may even contribute to community perceptions that all febrile illness is malaria or to resistance to drug therapy among community members.[19]

In this paper we present results from a rapid, nationally representative health facility survey and observational assessment of the status of diagnostic testing for malaria in Ghana and the Republic of Benin. The study assessed the quality and accuracy of interpretation of diagnostic testing for malaria (by the two main methods, RDTs and microscopic investigation of thick film blood slides) and HCWs' practices in the use of diagnostic testing for confirmation of suspected malaria cases and their adherence to their results in prescribing malaria treatment.

Materials and methods

Study design and sampling strategy

We used a cross-sectional study to assess malaria diagnostic capacity and patient care in 30 randomly selected facilities in each country. In Ghana, we took a list of all the country's publicly supported health facilities and excluded from it those not expected to have outpatient services and private facilities; the sample frame constituted the remaining 527 health facilities. In the Republic of Benin, public facilities were targeted, although sample frame lists included some private facilities; of 662 health facilities initially considered in the sample frame, only 135 met the inclusion criteria outlined below. In Ghana, 22 health centers and 8 hospitals were surveyed across 10 regions. In the Republic of Benin, 25 health centers and 5 hospitals were surveyed across 11 departments. In the Republic of Benin, preliminary data on patient loads were available through the health management information system (HMIS); only those facilities that reported seeing at least 10 outpatients per day were included. In Ghana, no such restriction was possible, as facility-level data were not available. In both countries, facilities that did not see outpatients (e.g., re-feeding centers) were excluded from the sampling frames. In Ghana, the 30 facilities were selected using simple random sampling (SRS) from those remaining on the list. In the Republic of Benin, 30 facilities were selected by SRS after stratification by six administrative zones; in instances where facilities had no patients present on the day of the survey, the closest facility at the same health-system level was selected as a replacement. Within each health facility, one outpatient department, one HCW and one laboratory were randomly selected for observation using simple random sampling where more than one option existed. The target sample size for clinician–patient observations, RDT or slide observations was 10 each per facility. All patients observed in patient–HCW interaction were targeted for patient exit interviews. A total of 266 patients were observed in Ghana and 272 in the Republic of Benin.

Data collection procedures

All data were collected during December 2012. At each selected facility, a modified service provision assessment (SPA) questionnaire, focused on malaria diagnostics and treatment, was administered to the health worker in charge; this was followed by HCW/patient observations, laboratory observations and patient exit interviews. The following data were also collected: patient registry records, samples of stored malaria blood slides, semistructured interviews with HCWs and laboratory technicians and the results of testing laboratory technicians on preprepared slide banks and RDT interpretation quizzes. All slides were collected and re-read off-site by blinded expert technicians (who all had advanced degrees and training in biomedical analysis or parasitology) to determine diagnostic accuracy. RDT readings were verified in the facility by trained data collectors immediately after the reading by the HCW. Survey instruments were translated into French for the Republic of Benin and into local languages in both countries as needed during interviews.

Informed consent was obtained in writing from all clinical and laboratory staff at the start of interviews. For observed patients, informed consent was obtained in writing from the patient. Where the patient was a child, consent was obtained from the child's parent or guardian; assent was also obtained from older children in addition to parental consent. Where written consent was not possible, oral consent was obtained after explaining the nature of the study to the participant.

Sample weights

Sample weights were calculated to adjust for unequal probabilities of individual survey respondent selection. For the patient–HCW interaction observations and patient exit interviews, weights were constructed using the average number of outpatients seen in the past 3 months at the facility (based on registry data). For the microscopy and RDT observations, weights were constructed based on the number of malaria tests conducted at the facility in the past 3 months. The formulae used to calculate the sample weights for 1. patient–HCW observations and exit interviews and 2. test observations were, respectively:

$$\frac{n}{N} \times \frac{P}{P_{3\,months}} \times \frac{1}{O} \times \frac{1}{C} = \frac{1}{weight_p} \quad (1)$$

$$\frac{n}{N} \times \frac{t}{t_{3\,months}} \times \frac{1}{L} \times \frac{1}{T} = \frac{1}{weight_t} \quad (2)$$

where n represents the number of facilities selected, N the number of facilities in the sample frame, P the number of patient HCW observations seen in a given cluster, $P_{3\,months}$ the number of patients seen in the facility over the past 3 months, O the number of outpatient departments at the facility, C the number of HCWs in the sampled outpatient department, L the number of laboratories that conduct malaria diagnosis at the facility, T the number of laboratory technicians who do malaria testing in the sampled

laboratory, t the number of tests observed at the facility, and $t_{3\,months}$ the number of tests conducted at the facility in the past 3 months. For Ghana, only the cluster-level weights (the n/N term) were identical across all facilities for each analysis because the sample was drawn using SRS with no stratification, and were therefore dropped from the above calculation.

Key indicators

Key indicators calculated included the following: sensitivity and specificity of malaria diagnostic test interpretation (i.e., the accuracy of the reading of the test performed, not the sensitivity and specificity of the test compared to a gold-standard re-test) as compared to a second independent test reader (i.e., trained personnel not part of the health facility staff) or, in the case of microscopy, to the most common finding of three independent readings; the proportion of individuals prescribed an antimalarial drug; the proportion of individuals prescribed an antimalarial drug that tested positive and negative for malaria; the proportion of patients with access to parasite testing; the proportion of patients tested (by type of diagnostic method); the proportion of patients with and without fever tested; and the proportion of laboratory-confirmed malaria cases in children aged <5 years and in children aged >5 years. For the sensitivity and specificity of the malaria diagnostic test interpretation, the re-reading of the slides via microscopy was done at a separate location by trained microscopists; this was a blinded exercise. For the re-reading of the RDT, a trained survey worker who was part of the data collection team performed the test re-reading at the same location.

Data entry and analysis

Data were double entered and reconciled in EpiData 3.1 (EpiData Association 2013, Odense M, Denmark) for Ghana and in Microsoft Access (Microsoft Corporation, Redmond WA, USA) for the Republic of Benin. Final data cleaning and analysis were conducted in Stata v.12.1 (Stata Corporation, College Station TX, USA).

The indicators were estimated after accounting for sampling weights to adjust for discrepancies in the ultimate probability of selection at facility, health worker, patient and laboratory sample levels. Standard errors were empirically estimated (using the Huber–White sandwich estimator) to account for correlated data resulting from the sampling design that meant we were selecting patients and laboratory tests within selected facilities (i.e., there was no national list of expected patients from which individual patients could be randomly selected, so facilities were first selected and then patients within those facilities). Accordingly, results are considered to be nationally representative. In Ghana, analysis of HCWs' use of and the actual application of diagnostics was restricted to facilities that had testing capacity on the day of the survey, as in other facilities a test could not have been provided even if requested. Further, a person was considered to be appropriately tested if they reported fever or a history of fever or had a measured temperature >37.5°C and a test had been requested.

A kappa statistic was used to assess the magnitude of agreement between the first and second slide readings. We used χ^2 statistics to test for statistically significant differences in indicator estimates. Multivariate logistic regression models (adjusted for survey structure using the survey prefix command svy in Stata) were used to assess which health facility, community and patient-level factors are associated with 1. receiving antimalarial drugs, 2. HCWs requesting a malaria test and 3. patients receiving a positive malaria diagnosis from the HCW (irrespective of parasitological confirmation).To control for clustering within facilities, the Huber–White sandwich estimator of variance was also used to calculate robust standard errors in logistic regression models, using the health facility as the cluster variable. Sample weights (as defined above) were also applied during regressions. In all models, key predictive variables were included a priori regardless of their statistical significance: facility type, country and fever; other variables were tested and not included in final models if insignificant: sex, age, cough and diarrhea.

Results

Table 1 presents un-weighted descriptive statistics for the sampled facilities and observed patients. Parasitological diagnosis was available in 100% of surveyed facilities in the Republic of Benin and 53.3% in Ghana. In the Republic of Benin, 81.2% (221/272) of surveyed patients reported or had a measured fever, with 87.9% (239/272) of febrile patients being tested for malaria. In Ghana, 91.1% (224/246) surveyed patients reported or had a measured fever but only 62.2% (117/188) were tested for malaria in facilities were testing was available. In the Republic of Benin, 280 parasitological malaria tests (RDTs and microscopy) were observed for procedural accuracy; 211 were observed in Ghana. Of the observed tests, RDTs contributed a significantly higher proportion of tests in the Republic of Benin (65.4%) versus Ghana (36.5%) (p=<0.01). Observed patients were primarily women, representing 52.4% of the sample (141/269) in the Republic of Benin and 66.5% (163/245) in Ghana. In the Republic of Benin, 37.1% of the surveyed patients (101/272) were children aged <5 years; in Ghana 25.2% of the surveyed patients (62/246) were children aged <5 years.

Figure 1 illustrates the sensitivity, specificity and accuracy of malaria microscopy readings for each country (i.e., how often independent slide re-readings were in concordance with the original slide result). Note: this analysis did not compare methods to a gold-standard re-test, only concordance between re-readings of the same test by expert microscopists. The kappa statistic for microscopy in Benin was 0.27 (p<0.001; n=153) and 0.70 (p<0.001; n=88) in Ghana. The weighted proportion of RDTs read correctly was 97.6 (176/183) (95% CI 94.7–1.00) in Benin and 1.00 (n=76) in Ghana.

Table 2 presents weighted estimates of the use of diagnostics at the facility level. In the Republic of Benin, 84.9% (95% CI 72.9–96.9) (n/N=239/272) of all patients received a malaria microscopy test or RDT, versus 65.7% (117/188) (95% CI 51.2–80.2) in Ghana; whereas in the Republic of Benin 89.4% (203/221) (95% CI 79.9–98.9) of febrile patients received a malaria microscopy test or RDT versus only 69.1% (110/172) (95% CI 53.9–84.3) in Ghana. In the Republic of Benin, 67% (15/51) (95% CI 40.1–94.3) of patients without reported or measured fever received a malaria microscopy test or RDT, versus 21% (7/16) (95% CI −10.8–52.8) in Ghana.

In addition to whether diagnostic tests were appropriately requested for febrile and non-febrile patients, the survey also evaluated how antimalarial drugs were prescribed in each country and

Table 1. Characteristics of sampled facilities and patients observed in a survey of malaria diagnostics in Ghana and the Republic of Benin, December 2012

	Benin		Ghana	
	N[a]	n (%)	N[a]	n (%)
Health and laboratory facilities				
Laboratory-confirmed or point-of-care diagnosis available	30	30 (100)	30	16 (53.3)
Facility type				
Hospital	30	5 (16.7)	30	8 (26.7)
Health center	30	25 (83.3)	30	22 (73.3)
Parasite diagnostics observed				
Microscopy	280	97 (34.6)	211	134 (63.5)
RDT	280	183 (65.4)	211	77 (36.5)
Microscopy slides collected for expert re-examination	153		84	
Patient observation data				
Patients reporting fever, history of fever or with measured fever (≥37.5°C)	272	221 (81.2)	246	224 (91.1)
Patients with a malaria test requested	272	239 (87.9)	246	117 (62.2)[b]
Patients diagnosed with malaria[c]	272	148 (54.4)	246	181 (73.6)
Patients receiving parasite test results	272	205 (75.4)	246	103 (41.9)
Patient descriptive statistics				
Female	269	141 (52.4)	245	163 (66.5)
Children aged <5 years	272	101 (37.1)	246	62 (25.2)

RDT: rapid diagnostic test.
[a] N refers to the denominator in our sample, not the total facilities in our sample frame.
[b] N=188 restricted to only facilities with available testing on the day of the survey.
[c] Clinical or parasitological diagnosis.

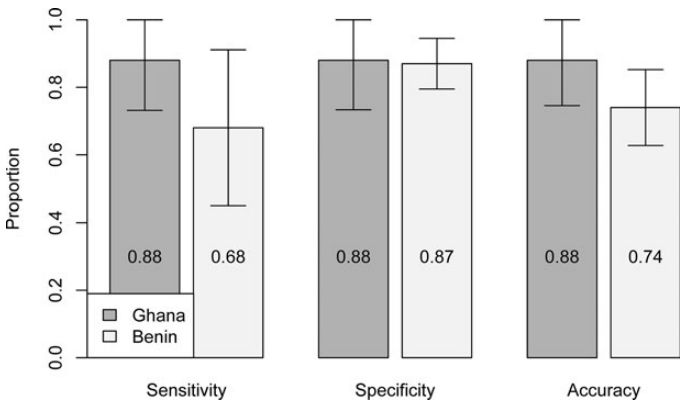

Figure 1. Sensitivity, specificity and accuracy of malaria microscopy interpretation in Ghana and the Republic of Benin observed in a survey of health facilities in December 2012. Note: Sensitivity is defined as the proportion of positive slides identified as being positive by the expert reader; specificity is defined as the proportion of negative slides identified as being negative by the expert reader; accuracy is defined as the overall proportion of slides read correctly.

whether patients receiving a diagnosis of malaria had parasite confirmation (Table 3). In Ghana, 66.5% (163/246) (95% CI 55.9–77.0) of patients received an antimalarial and in the Republic of Benin 49.9% (140/242) (95% CI 36.3–63.5) of patients received an antimalarial (Note: all facilities visited had antimalarial drugs in stock at the time of the survey.) Adherence to a positive test result (i.e., the health worker followed policy and gave antimalaria drugs) was 85% (56/64) (95% CI 72.2–98.7) and 84% (74/81) (95% CI 68.7–98.4) of patients with a positive parasitological test receiving an antimalarial in Ghana and the Republic of Benin, respectively. However, non-adherence to negative test results (i.e., patients receiving an antimalarial despite having a negative parasitological test) was estimated to be 30% (12/39) (95% CI 11.1–49.0) and 37.8% (44/124) (95% CI 22.6–53.0) in Ghana and the Republic of Benin, respectively. Parasitological confirmation of a malaria diagnosis in children aged <5 years was 29% (19/44) (95% CI 11.1–46.8) in Ghana and 55% (34/62) (95% CI 24.3–65.6) in the Republic of Benin. In some cases a test had been requested but no test result was available, which may have occurred because the survey team or the patient left the facility before microscopy results were available. When the above analysis was restricted to only those with test results available, parasitological confirmation of a malaria diagnosis increased to 91% (19/20) (95% CI 69.0–1.12) in Ghana and 85% (34/47) (95% CI 65.9–1.04) in the Republic of Benin.

Results of a logistic regression model testing factors associated with patients receiving a malaria diagnosis (i.e., diagnosis by HCW, irrespective of parasitological confirmation) suggest that individuals who received a positive malaria test result had increased odds of receiving a malaria diagnosis from the HCW compared to those not receiving a test result (adjusted odds ratio [AOR] 14.89; 95% CI 5.04–43.98; p<0.001). Patients who received

Table 2. Use of malaria diagnostic testing for patients with and without fever (weighted percentages) observed in Ghana and the Republic of Benin, December 2012, in a survey of healthcare facilities

	Benin			Ghana		
Characteristic	N[e]	n (%)	95% CI	N[e]	n (%)	95% CI
Patients with access to parasite yesting	272	272 (100)	–	246	188 (82.0)	65.2–98.6
All patients tested by RDT or microscopy[a]	272	239 (84.9)	72.9–96.9	188	117 (65.7)	51.2–80.2
RDT	272	164 (41.2)	20.4–65.7	188	43 (16.4)	6.8–34.3
Microscopy	272	59 (36.2)	17.1–60.9	188	64 (41.4)	24.7–60.3
RDT and microscopy[b]	272	16 (7.5)	1.9–24.98	188	10 (7.9)	1.9–27.5
Patients with fever tested[c]	221	203 (89.4)	79.9–98.9	172	110 (69.1)	53.9–84.3
RDT	221	135 (40.6)	20.4–64.6	172	40 (16.9)	7.1–34.9
Microscopy	221	54 (41.4)	20.9–65.2	172	60 (43.7)	25.0–64.4
RDT and microscopy	221	14 (7.4)	2.2–22.6	172	10 (8.5)	2.1–28.8
Patients without fever tested[d]	51	15 (67.2)	40.1–94.3	16	7 (21.0)	10.8–52.8
RDT	51	29 (43.6)	15.5–76.4	16	3 (10.0)	1.2–51.8
Microscopy	51	5 (15.9)	2.5–57.7	16	4 (10.9)	1.8–44.9
RDT and microscopy	51	2 (7.8)	12.5–62.5		–	–

RDT: rapid diagnostic test.
[a] Restricted to where testing was available.
[b] Patients received both types of test.
[c] In Ghana, 57.4% (95% CI 39.6–73.5) of febrile patients (n=224) were tested, when not restricted to whether testing was available in the facility.
[d] In Ghana, 17.5% (95% CI 4.1–51.2) of non-febrile patients (n=22) were tested, when not restricted to whether testing was available in the facility.
[e] N refers to the denominator in our sample, not the total facilities in our sample frame.

Table 3. Use of antimalarial drugs for patients and parasitological confirmation of malaria diagnosis (weighted percentages) observed in Ghana and the Republic of Benin in December 2012, in a survey of healthcare facilities

	Benin			Ghana		
	N[d]	n (%)	95% CI	N[d]	n (%)	95% CI
Antimalarial prescriptions						
Prescribed an antimalarial	242	140 (49.9)	36.3–63.5	246	163 (66.5)	55.9–77.0
Test positive and prescribed antimalarial[a]	81	74 (83.6)	68.7–98.4	64	56 (85.4)	72.2–98.7
Test negative and prescribed antimalarial[a]	124	44 (37.8)	22.6–53.0	39	12 (30.1)	11.1–49.0
Malaria diagnosis confirmation						
Patients aged >5 years with parasitological confirmation[a,b]	86	39 (29.1)	18.8–39.5	94	45 (46.2)	22.3–70.0
Patients aged <5 years with parasitological confirmation[a,c]	62	34 (55.3)	24.3–65.6	44	19 (29.0)	11.1–46.8

[a] Restricted to where testing was available; N varies because of conditional restrictions.
[b] In Ghana, 36.6% (95% CI 16.3–56.9) of patients aged >5 years (n=132) had parasitological confirmation of malaria diagnosis, when not restricted to whether testing was available at the facility.
[c] In Ghana, 27% (95% CI 11.0–43.9) of patients aged <5 years (n=49) had parasitological confirmation of malaria diagnosis, when not restricted to whether testing was available at the facility.
[d] N refers to the denominator in our sample, not the total facilities in our sample frame.

negative test results had reduced odds of receiving a malaria diagnosis from the HCW(AOR 0.50; 95% CI 0.23–1.10; p=0.08) when receiving a negative test result compared to not receiving a test result, suggesting that HCWs often appropriately respond to negative parasitological test results in routine settings, although this estimate was marginally insignificant. Patients

with fever or diarrhea had an increased odds of receiving a malaria diagnosis (fever: AOR 2.15, 95% CI 1.12–4.13, p<0.05; diarrhea: AOR 1.84, 95% CI 1.16–2.93, p<0.05), as compared to patients who did not have a fever or diarrhea as symptoms, even after controlling for test results; whereas, patients who had a cough or skin problem had reduced odds of receiving a malaria diagnosis (cough: AOR 0.58, 95% CI 0.38–0.87, p<0.05; skin problem: AOR 0.31, 95% CI 0.13–0.74) when compared to patients who did not have a cough or skin problem after controlling for test results. Other variables tested but not significant were clinical signs and symptoms, type of healthcare worker, patients reporting ACT use before the current visit, age of patient, sex of patient, and an interaction between malaria test type and malaria test results.

Results of a logistic regression model testing factors associated with HCWs requesting a malaria test for a patient suggest that, when compared to being a patient at a health center, being a patient at a hospital was associated with reduced odds of having a malaria test (AOR 0.33, 95% CI 0.12–0.87, p<0.05). By contrast, being a patient in the Republic of Benin or having a fever increased an individual's odds of having a malaria test requested (Republic of Benin: AOR 4.45, 95% CI 1.80–10.96, p<0.01; fever: AOR 4.29, 95% CI 2.46–7.45, p<0.001), respectively. Other variables tested but not significant were clinical signs and symptoms, age of patient, and sex of patient.

Results of the logistic regression analysis for patients receiving an antimalarial drug suggest that malaria diagnosis (irrespective of test result) was the strongest predictor of a patient receiving an antimalarial drug, with an AOR of 13.4 (95% CI 6.78–26.56; p<0.001). An individual receiving a positive malaria test result versus not receiving any malaria test result was eight times more likely to receive an antimalarial (AOR: 6.99; 95% CI 2.99–16.34; p<0.001). Lastly, the presence of parasite testing at the facility was strongly associated with reduced odds of a patient receiving an antimalarial drug (AOR 0.16; 95% CI 0.07–0.34; p<0.001) when compared to patients at facilities without testing. Other variables tested but not significant were health facility type, presence of a fever (>37°C), country, age of patient and sex of patient. For all models, interaction terms were tested between country and independent variables; no significant differences were detected.

Discussion

There are several key findings from this study. First, laboratory diagnostic test interpretation was accurate most of the time. Second, HCWs appropriately prescribed drugs when a positive test was found, although many patients testing negative also received a prescription for antimalaria drugs. And third, testing availability varied between Ghana and the Republic of Benin.

The results demonstrate that the interpretation of malaria microscopy, as applied in routine practice, was accurate most of the time in these two countries, adding to the evidence base that quality parasitological diagnosis is being performed at health facilities in Ghana and the Republic of Benin. Data from National Malaria Programs across Africa suggest that access to diagnostics for malaria has increased dramatically over the past 12 years, with the proportion of suspected malaria cases given a diagnostic test increasing from around 15% to more than 60%.[1] Results from available household surveys conducted between 2010 and 2012 across 14 countries suggest, however, that the estimated proportion of febrile children who sought care and received parasitological testing was varied and somewhat low, with testing rates in private facilities ranging from approximately 3 to 34%, and testing rates in public facilities ranging from around 10 to almost 55%.[1] A meta-analysis of recent household survey datasets suggests that coverage of diagnostic testing among all febrile children was lower, ranging from 5.3 to 27.0%.[6] No household survey data from Ghana or the Republic of Benin was available to generate a comparable estimate. The use of household survey data to estimate testing rates at health facilities may be subject to recall bias and misclassification; a validation study conducted in Zambia showed that recall of a finger/heel stick to obtain a capillary blood sample showed a sensitivity of only 62%.[20] A previous health facility survey in Ghana (2008) found that fewer than half of facilities had laboratory services available on the day of the survey and only 20% of patients with a malaria diagnosis had a laboratory test ordered. This study also found that same-day laboratory results were rarely (24% of the time) available in Ghana.[21] While those findings were not directly comparable with the indicators estimated in this study, it seems likely that this study's findings indicate that there has been an expansion in access to and usage of malaria laboratory testing in Ghana since 2008.

On most occasions when malaria tests were performed, HCWs prescribed drugs in line with positive malaria test results. This finding is similar to those of other studies, including controlled trials and observational studies in sub-Saharan Africa.[7,22] Indeed, given that historically malaria has been presumptively and widely overdiagnosed and treatments correspondingly overused, it is not surprising that a confirmatory positive test results in high apparent adherence to the test result. However, many patients with negative parasitological test results still received ACTs (30% and 38% in Ghana and the Republic of Benin, respectively), suggesting that in many cases HCWs do not withhold antimalarial drugs despite having diagnostics that indicate an absence of parasite infection in their patients. This finding is similar to findings from other observational studies and clinical trials in SSA.[7,23] Despite widespread access to diagnostics that are reasonably sensitive and accurate, HCWs in many cases prescribe antimalarial drugs to patients with negative parasitological tests. The reasons behind this pattern of behavior are not completely clear and are likely to be highly contextually dependent.[9,23,24] In many settings the introduction of RDTs has led to large reductions in the use of ACTs,[9,22,23,25] while in other settings the introduction of RDTs has resulted in little change in provider prescription behavior.[9,23]

The World Malaria Report 2013 shows an increasing trend in the proportion of estimated presumed and confirmed malaria cases treated with ACT. In 2005 <20% of cases worldwide were being treated with ACT; by 2012 the proportion was closer to 60%.[1] Improved use of diagnostics and subsequent rational use of ACTs and antibiotics could result in improved patient outcomes and resource savings.[8,10,26] Unfortunately if providers continue to prescribe antimalarial drugs to patients testing negative, much of the potential resource savings and potential improvements in outcomes from better targeted treatments may not be realized. This suggests that interventions to improve HCWs' adherence to and trust in negative test results should probably be implemented.

Changing health facility worker behavior is a challenging prospect, especially when the HCW's behavior is not strictly rational, as may be the case when tests are requested and then negative

results are ignored.[24,27,28] Continuing education, training and reinforcement of rational prescription practices that follow national policy for malaria case management may help to improve the rational use of test results in prescribing practice, but the specifics of the types and methods for education, outreach and training and reinforcement will play a part in its ultimate effectiveness and potentially the duration of effect.[29–34] Given previous guidance on antimalarial prescribing practices under previous WHO and Integrated Management of Childhood Illness (IMCI) guidelines (e.g., that in endemic areas all children aged <5 years should be treated with an antibiotic and an antimalarial) it is certainly plausible that many HCWs continue to follow this guidance. As such, communicating to HCWs the safety of withholding antimalarial drugs in the presence of negative test results may also be necessary; the safety of this approach has been shown in several studies and is endorsed by WHO.[2,35,36] It may also be important to communicate the importance of ruling out malaria, and subsequently the need to find an alternative diagnosis that can then be properly managed.

Context-specific education strategies to expand access to and improve the quality of diagnostics should target facility staff responsible for malaria case management, to reinforce the importance of parasitological confirmation. Patient-mediated approaches to increase demand for malaria testing and appropriate treatment might also offer a promising approach, as such strategies have been found to be effective in combination with continuing physician education in other medical domains.[30] While the overall accuracy of malaria microscopy was reasonably high in this study, support for monitoring and supportive supervision within or to facilities (both public and private) need to be expanded or continued to ensure quality control and assurance practices are followed for diagnostics and that treatment decisions rely on the results of those diagnostics.

The Republic of Benin and Ghana were selected for the study because they were part of a bilateral program to improve the quality and accuracy of malaria laboratory diagnostics in sub-Saharan Africa. These two surveys were conducted rapidly and at low cost, but produced valid nationally representative estimates of the coverage of diagnostics, accuracy of diagnostic test interpretation and adherence to test results in prescribing practices for antimalarial drugs. The survey methods used could be useful for national and global monitoring of malaria diagnostic tests and prescribing practices.

Limitations

While study teams collected results of diagnostics that were available on the day of the survey, in many cases, especially in the Republic of Benin, same-day microscopy results for ordered tests were not available and survey teams therefore could not ascertain final test results for these patients. While the facility surveys were conducted rapidly and at low cost, the limited sample size meant that there were wide confidence bands around point estimates and limited power for detecting adjusted associations with important indicator values. Furthermore, while in recent years the lists of health facilities managed by ministries of health in sub-Saharan Africa have improved enormously, it remains challenging to develop an accurate and exhaustive sample frame of public sector health facilities, and incompleteness of the sample frame could lead to bias in the estimates of coverage. Moreover, these surveys excluded community health workers, private facilities in Ghana, and facilities with small historically reported numbers of malaria cases in the Republic of Benin. Further, in the Republic of Benin, six private health facilities were included in the final sample to replace health facilities with no patients present on the day of the survey. Collectively, these issues limit the potential representativeness of the results. Re-reading of the RDT by data collectors may have been influenced by the health worker's reading of the test, as the re-reading was done at the same location and shortly after the initial reading of the RDT by the health worker. Our survey workers were trained to independently evaluate the RDT result, and given the time-limited nature of RDT result interpretation no other approach to evaluating the accuracy of the health workers test interpretation was possible.

It is possible that being the subject of investigation influenced the centers' performance. There was, however, extensive effort to ensure that all health workers were aware that the survey data could not be used to evaluate their performance or the performance of the health center specifically but rather would be used to provide general insight into steps that could be taken to improve health service delivery, that HCW and laboratory technician names were not recorded and there was no possibility of linking the results of the study back to specific HCWs or facilities.

Conclusions

Overall, the results of these surveys indicate that diagnostics for malaria are often performed adequately and accurately in health facilities in Ghana and the Republic of Benin, although diagnostic coverage at the facility level remains incomplete, particularly in Ghana. Interventions to improve HCW adherence to testing protocols and prescribing practices are necessary to convince HCWs to withhold antimalarial drugs from test-negative patients and to ensure testing of all febrile patients. While this study was cross-sectional and covered only one time point, contextual evidence from other research indicates that there has probably been an overall improvement in availability and usage of malaria diagnostics in the Republic of Benin and in Ghana over the past 5–10 years.

Authors' contributions: JK and JOY conceived the study; JK, JOY and TPF designed the study protocol; JOY and TPF carried out data quality control and supervision of data collection; JOY, JK and TPF conducted the analysis and interpretation of these data. JK, TPF, and JOY drafted the manuscript; JK, JOY, TPE, MK, BF, EB, GD and TPF critically revised the manuscript for intellectual content and provided edits and text. All authors read and approved the final manuscript. JK and JOY are guarantors of the paper.

Funding: This work was funded by the US Agency for International Development (Washington DC, USA) under Cooperative Agreement [GHS-A-00-07-00022-00], awarded to Medical Care Development International (MCDI) to support the President's Malaria Initiative (PMI) Improving Malaria Diagnostics Activity (IMaD); a sub-contract was awarded to Tulane University School of Public Health and Tropical Medicine, New Orleans LA, USA, to conduct the evaluation.

Competing interests: None declared.

Ethical approval: This study was approved by the institutional review board of Tulane University, School of Public Health and Tropical Medicine,

the Ethical Review Committee of the Ghana Health Services (GHS-ERC), Accra, Ghana and the Comité d'Ethique de la Recherche–Institut des Sciences Biomédicales Appliquées (CER-ISBA), Cotonou, Republic of Benin.

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