How Far Are We from Reaching Universal Malaria Testing of All Fever Cases?

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Abstract. Universal malaria diagnostic testing of all fever cases is the first step in correct malaria case management. However, monitoring adherence to universal testing is complicated by unreliable recording and reporting of the true number of fever cases. We searched the literature to obtain gold-standard estimates for the proportion of patients attending outpatient clinics in sub-Saharan Africa with malarial and non-malarial febrile illness. To correct for differences in malaria transmission, we calculated the proportion of patients with fever after excluding confirmed malaria cases. Next, we analyzed routine data from Guinea and Senegal to calculate the proportion of outpatients tested after exclusion of confirmed malaria cases from the numerator and denominator. From 12 health facility surveys in sub-Saharan Africa with gold-standard fever screening, the median proportion of febrile illness among outpatients after exclusion of confirmed malaria fevers was 57% (range: 46–80%). Analysis of routine data after exclusion of confirmed malaria cases demonstrated much lower testing proportions of 23% (Guinea) and 13% (Senegal). There was substantial spatial and temporal heterogeneity in this testing proportion, and testing in Senegal was correlated with malaria season. Given the evidence from gold-standard surveys that at least 50% of non-malaria consultations in sub-Saharan Africa are for febrile illness, it appears that a substantial proportion of patients with fever are not tested for malaria in health facilities when considering routine data. Tracking the proportion of patients tested for malaria after exclusion of the confirmed malaria cases could allow programs to make inferences about malaria testing practices using routine data.

INTRODUCTION

Malaria symptoms are nonspecific, and any febrile illness in most malaria-endemic settings should be considered a suspect case of malaria. In 2010, the World Health Organization (WHO) recommended universal testing of all suspect uncomplicated malaria cases before treatment,¹ in an effort to move away from decades of clinical diagnosis and treatment of malaria. Rapid diagnostic tests (RDTs), which were introduced widely in sub-Saharan Africa during the last decade, made point-of-care parasitological confirmation of malaria infection possible in low-resource settings where microscopy was not available.

Even as endemic country governments and donors have invested heavily in procurement, supply chain management, and distribution of RDTs; support for microscopy; and training and supervision of health-care workers, it is not clear what proportion of suspect malaria cases are tested as a result. For a patient presenting to a health facility with febrile illness to receive correct case management for malaria, diagnostic tests must be in stock, and the health-care worker must inquire as to fever or history of fever if this information is not volunteered, make the decision to perform an RDT, perform and interpret the RDT correctly, and administer treatment indicated by the results. Although many countries have acceptable stock reporting systems, and many studies have documented the quality of health-care worker performance of RDTs and adherence to test results,^{2,3} few have studied health-care worker performance in the crucial step of identifying and testing patients with febrile illness.

Recent surveys that have measured whether health-care workers assessed presence of febrile illness through observation of consultations found that presence of febrile illness

was assessed in 74–93% of consultations among children younger than 5 years, and those surveys that observed consultations among those older than 5 years found that fever was less often assessed among these older patients.^{4–9} A health facility survey in Madagascar found that less than 50% of patients identified by health-care workers as having a febrile illness were identified as suspect malaria cases.⁹ A meta-analysis of 13 national community-based surveys conducted from 2009 to 2012 found that of the 26.5% of children younger than 5 years for whom fever was reported in the previous 2 weeks, only 16.9% had received diagnostic testing. Among those who sought care, the proportion tested ranged from 35.3% in hospitals to 16.5% at the community level.¹⁰

Most outpatient registers in endemic countries do not have a specific field for fever, and in those that do, such as Uganda, completeness rates are low (N. Westercamp, personal correspondence), making retrospective register review unreliable. This inconsistent recording and reporting of the number of fever cases means that it is difficult to determine the true number of suspect malaria cases. As a result, in many routine malaria surveillance systems, suspect malaria cases are in practice tautologically reported as the total number of patients tested for malaria, and testing rates are consequently often reported near or at 100%,^{11,12} giving an overly rosy picture of testing practices.

Health facility surveys characterizing the true testing rate for febrile illness have consistently shown that, contrary to the high testing rates of suspect malaria cases often reported through routine systems, the testing step is the weakest link in the health facility malaria case management pathway, with the failure to identify and test suspect malaria cases (patients with fever or history of fever in the previous 48 hours) being the most common error observed through these surveys.^{5,13–16} However, few of these kinds of surveys have been published, and because they depend on dedicated survey teams traveling to health facilities to interview or observe patients, they are

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expensive and impractical for continuous longitudinal monitoring of testing practices across all health facilities at a national level. Many programs have instituted health facility supervision visits as an alternative for assessing malaria case management practices, usually reviewing registers retrospectively to assess adherence to proper practice for identifying and testing suspect malaria patients. However, in the absence of rigorously recorded fever, a retrospective review of patient registers with providers may not be effective in detecting and correcting incorrect testing practices. Some advocate monitoring the proportion of all outpatient consultations for which a malaria diagnostic test is performed. However, this is highly dependent on the background level of malaria transmission, and this proportion will be elevated in zones with large numbers of malaria cases compared with those with fewer cases, impeding the comparison of performance across facilities or areas with differing proportions of malaria cases.

Here, we propose an alternative approach to understanding malaria testing practices using routinely recorded data from health facilities, based on analysis of the number of all-cause outpatient acute care consultations, the number of patients tested for malaria, and the number of patients who test positive, all indicators commonly collected by routine health information systems. We calculate a corrected testing proportion by removing the number of patients with confirmed malaria from both the numerator and denominator ($[\text{patients tested} - \text{patients who test positive}] / [\text{all consultations} - \text{patients who test positive}]$), which is equivalent to $(\text{patients who test negative} / \text{patients without malaria})$. How do we interpret this corrected testing proportion?

First, we assume that there is likely to be a relatively consistent rate of consultations for nonfebrile illnesses, which, if all patients with febrile illness were tested, would be the number of all-cause consultations minus the number of patients tested for malaria. If all patients with febrile illness were tested, the number of non-malaria fevers would be the number of patients tested minus the number of positive tests. We demonstrate that although there may be some seasonal fluctuation of non-malaria febrile illness, there is likely to be a minimum underlying rate of non-malaria febrile illness among patients attending outpatient clinics, and consequently that there is a minimum anticipated proportion of non-malarial fever consultations among all non-malaria consultations. We demonstrate that there is, therefore, an underlying anticipated minimum proportion of non-malaria febrile illnesses among all non-malaria consultations, and that if all febrile illnesses are being tested, this minimum proportion should be reached by dividing all patients who test negative for malaria by the number of all non-malaria consultations. If this calculation is performed using data generated by routine health information systems ($[\text{patients tested for malaria} - \text{patients who test positive}] / [\text{all-cause consultations} - \text{patients who test positive}]$) and this proportion falls substantially below that minimum proportion, this suggests that a large proportion of febrile patients may not be receiving tests for malaria, even if the reported proportion of suspected cases reported as tested is close to 100%.

METHODS

We performed a two-part analysis of previously collected data. First, we re-analyzed data from health facility surveys to

estimate true fever rates among outpatients. Next, we analyzed routine data to compare real-world testing practices with the true fever rates.

Estimation of true fever and appropriate testing rates among outpatients. We searched the published literature for health facility surveys in sub-Saharan Africa that included systematic evaluation of patients for the presence of current and history of fever by survey teams. We excluded surveys that relied on unprompted reporting of fever by the patient or health-care worker assessment of fever. We relied on the original study's definition of febrile illness; most studies defined febrile illness as measured fever during the health facility visit or history of fever in the last 24 or 48 hours. We classified patients into three categories: malaria fevers (A), defined as patients with febrile illness that tested malaria positive either during re-examination by the survey teams or during the health facility visit; non-malaria fevers (B), defined as patients with febrile illness that tested malaria negative; and patients without fever (C). For the surveys that did not include malaria testing by the survey team of all febrile participants, febrile patients without a malaria test result were assigned into the A and B groups based on the overall test positivity rate among patients who were tested. The number of patients with febrile illness that should be tested was, thus, $A + B$. We calculated the proportion of fevers among all-cause patient consultations as $(A + B) / (A + B + C)$, and the corrected proportion of fever after exclusion of malaria fevers as $B / (B + C)$. Whenever possible, we performed the analysis separately for patients younger and older than 5 years.

Characterization of testing rates from routine data. We obtained routine monthly data on all-cause patient consultations, total confirmed malaria cases, and total patients tested from January 2013 to December 2017 from the National Malaria Control Program database in Senegal, and for January 2016 to December 2016 from the National Malaria Control Program database in Guinea. We also abstracted summarized annual data from 2015 on these indicators from data submitted by endemic countries to the WHO for the World Malaria Report, 2016.¹⁷ We classified outpatients into three groups: confirmed malaria cases (A^*); patients that tested negative for malaria (B^*), calculated as the number of confirmed cases subtracted from the total tested; and non-tested patients (C^*), calculated by subtracting the total tested from the total number of all-cause outpatient visits. (If all febrile patients are tested, $A = A^*$, $B = B^*$, and $C = C^*$.) We calculated the crude fever testing proportion as the proportion of patients tested for malaria among all-cause outpatient visits as $(A^* + B^*) / (A^* + B^* + C^*)$. We defined the corrected fever testing proportion as the proportion of patients tested after exclusion of confirmed malaria fevers from the numerator and denominator: $B^* / (B^* + C^*)$.

We plotted the corrected fever testing proportion by health district for Senegal and for Guinea for March 2016, representing low malaria transmission season in each country, and for September 2016, representing high-transmission season. For Senegal, which had complete routine data available for 5 years, we plotted the annual crude and corrected fever testing proportion from 2013 to 2017, stratified by age group and by four transmission intensity zones. We compared the overall corrected fever testing proportion versus the crude testing proportion in 2016 for Guinea and Senegal for each district. Finally, we plotted the overall annual corrected fever testing proportion for all malaria-endemic sub-Saharan African

countries for 2015 with available data in the WHO World Malaria Report database.

The analysis was classified as non-research by Centers for Disease Control and Prevention Human Subjects Review.

RESULTS

Gold-standard health facility surveys. We found 12 health facility surveys with systematic fever screening of all outpatient consultations (Table 1) from seven countries in west,^{18,19} central,^{16,20} southern,^{4,5,9,21,22} and east Africa.^{23,24} Although all surveys that included patients of all ages reported proportion of patients with fever stratified by children younger than 5 years and patients 5 years and older, not all reported confirmed malaria cases by age group. The median proportion of outpatients younger 5 years that presented with a febrile illness was 81%, and ranged from 68% to 94%. After exclusion of fevers because of malaria from the numerator and denominator, the median corrected proportion of outpatients younger than 5 years with a febrile illness was 66%, ranging from 56% to 89%. Among patients 5 years and older, the median proportion of patients with febrile illness was 59%, and ranged from 56% to 82%. After exclusion of fevers due to malaria, the median corrected proportion of febrile illness fell

to 49%, ranging from 42% to 75%. Among patients of all ages, the median overall corrected proportion of febrile illness after exclusion of malaria fevers was 57%, and ranged from 46% to 80%, with only one under 50%. Among patients of all ages, although there was moderate correlation between the proportion of all consultations with fever and the proportion with malaria infection ($R^2 = 0.40$), there was no correlation between the corrected proportion and the proportion with malaria infection ($R^2 < 0.001$).

Routine surveillance systems. Analysis of routine surveillance data showed that the proportion of patients tested for malaria after correction for confirmed malaria cases rarely reached these levels. The overall corrected fever testing proportion for 2016 was 13% in Senegal and 23% in Guinea, compared with a median of 19% for 39 malaria-endemic countries in sub-Saharan Africa for which data were available (Supplemental Figure 1). In both Guinea and Senegal, there was substantial geographic variation in the corrected fever testing proportion. In general, coastal and northern Guinea had substantially higher testing than the rest of the country (Figure 1). In Senegal, districts in the southeast, where malaria transmission is higher, generally tested more than the remainder of the country, where transmission is lower. There were substantial seasonal differences in both Senegal and

TABLE 1

Rates of malaria fevers, non-malaria fevers, and non-febrile illness among all-cause outpatient visits, as assessed during health facility surveys with explicit fever screening

Country	Ref.	Year of study	Sample size	Malaria season	Malaria transmission*	Age group	Gold-standard testing of all fever cases†	% Fever‡	% Malaria fevers (A)	% Non-malaria fevers (B)	% Non-febrile illness (C)	% Fever excluding malaria cases (B/[B + C])
Malawi	22	1993	1,124	Peak	High	< 5	Yes	87%	60%	28%	13%	69%
Gambia	19	1993–1994	440	All year	High	< 5	Yes	92%	32%	60%	8%	88%
Tanzania	24	1997	652	High	High	< 5	Yes	75%	28%	47%	25%	65%
Benin	18	1999	397	Peak	High	< 5	No	86%	\$	\$	\$	\$
Angola	20	2007	72	Low	Low	< 5	No	81%	\$	\$	\$	\$
Malawi	5	2011	806	Peak	High	< 5	Yes	94%	46%	48%	6%	89%
Malawi	4	2013–2014	3,149	All year	High	< 5	No	67%	37%	30%	33%	56%
Kenya	23	2013–2015	23,504	All year	High	< 5	Yes	77%	39%	38%	23%	63%
Madagascar	9	2014	136	High	Low	< 5	Yes	80%	–	–	–	–
Malawi	4	2015	723	Peak	High	< 5	No	85%	\$	\$	\$	\$
Angola	16	2016	222	Peak	Low	< 5	Yes	68%	6%	62%	32%	66%
Angola	16	2016	162	Peak	High	< 5	Yes	79%	47%	31%	21%	60%
Angola	20	2007	105	Low	Low	≥ 5	No	58%	\$	\$	\$	\$
Malawi	5	2011	1,209	High	High	≥ 5	Yes	82%	29%	53%	18%	75%
Kenya	23	2013–2015	48,537	All year	High	≥ 5	Yes	63%	28%	35%	37%	49%
Madagascar	9	2014	83	High	Low	≥ 5	Yes	56%	\$	\$	\$	\$
Malawi	4	2015	1,619	High	High	≥ 5	No	69%	\$	\$	\$	\$
Angola	16	2016	368	Peak	Low	≥ 5	Yes	56%	11%	45%	44%	51%
Angola	16	2016	472	Peak	High	≥ 5	Yes	59%	29%	30%	41%	42%
Angola	20	2007	177	Low	Low	All ages	No	67%	16%	51%	37%	61%
Malawi	5	2011	2,105	High	High	All ages	Yes	87%	34%	53%	13%	80%
Kenya	23	2013–2015	72,401	All year	High	All ages	Yes	68%	32%	36%	32%	53%
Madagascar	9	2014	219	High	Low	All ages	Yes	61%	5%	56%	39%	59%
Malawi	4	2015	2,096	High	High	All ages	No	73%	38%	35%	27%	55%
Angola	16	2016	590	High	Low	All ages	Yes	61%	9%	52%	39%	57%
Angola	16	2016	634	High	High	All ages	Yes	64%	33%	30%	36%	46%

* High defined as > 30% *P. falciparum* test positivity rate.

† For surveys without gold-standard testing of all fever cases by survey teams (testing by rapid diagnostic test or microscopy for all fever cases by study teams), the breakdown of malaria fevers (A) and non-malaria fevers (B) was imputed by applying the observed test positivity rate.

‡ As assessed by survey team.

\$ Results disaggregated by age not reported.

Guinea, with more testing during the wet season than in the dry season (Figures 1 and 2A). In Senegal, the crude testing proportion varied substantially from rainy to dry season with the variation in the number of malaria cases, with less seasonal variation in the corrected testing proportion (Figure 2A). In contrast to the crude testing proportion which did not show any year-by-year trend following 2015, the corrected testing proportion showed a consistently increasing trend (Figure 2A and B). Although the corrected testing proportion was lower for children younger than 5 years than for older patients during 2013 and 2014, starting in 2015, the corrected testing proportion for children younger than 5 years increased relative to older patients. Despite some remaining seasonal variation, starting in 2015, the corrected testing proportion remained high during dry season for children younger than 5 years. Starting in 2015, the corrected testing proportion for older patients increased during transmission season. The corrected

testing proportion increased further in mid-2017, when the NMCP announced a policy of universal testing of all patients with febrile illness, regardless of age or transmission season (Figure 2A).

Among all districts from Guinea and Senegal, there were several districts that had testing patterns consistent with those from our analysis of the health facility survey data with systematic fever screening: a stable and substantial proportion of patients that tested negative for malaria, a stable proportion of patients not tested for malaria, and a high corrected fever testing proportion (Figure 3). The consistency of the proportion of non-tested patients and patients that tested malaria negative was particularly notable when contrasted to the seasonal variability in the number of confirmed malaria cases.

By contrast, there were many examples of districts with testing practices that differed from those expected based on

FIGURE 1. Corrected fever testing proportion, defined as the proportion of all-cause outpatients tested for malaria after exclusion of confirmed malaria cases, by district in Guinea and Senegal during low malaria transmission season (March) and high malaria transmission season (September). Gray represents districts with missing data for the given month.

FIGURE 2. (A) Test positivity rate, crude fever testing proportion, and corrected fever testing proportion, defined as the proportion of all-cause outpatients tested after exclusion of confirmed malaria cases, by age group in Senegal for the period 2013–2017. (B) The crude and corrected fever testing proportion, stratified by transmission zone, Senegal, 2013–2017.

the analysis of the health facility survey data (Figure 4). In the Siguiri District in northeast Guinea, the corrected fever testing proportion was very low throughout the year. The number of negative tests for malaria was exceedingly low, and there was a dramatic increase in non-tested patients from June to December, precisely coinciding with malaria transmission season, suggesting a large number of missed malaria diagnoses. In the Tambacounda District in southeast Senegal, which

has relatively high malaria transmission compared with most of the country, the number tested and the corrected fever testing proportion increased substantially during the rainy season compared with the dry season, and the number of non-tested patients decreased during the peak months of transmission (October–November), suggesting relatively insufficient testing during the dry season. In the Keur Momar Sarr District in north-central Senegal, which has relatively low

FIGURE 3. Breakdown of all-cause outpatient consults into confirmed malaria cases (blue), patients testing negative for malaria (green), and non-tested patients (red) for two districts with good apparent malaria testing practices: Forécariah in Guinea and Salamata in Senegal. Dashed line represents the crude fever testing proportion, defined as the proportion of all-cause outpatients tested for malaria, and solid line indicates corrected fever testing proportion indicator, defined as the proportion of all-cause outpatients tested after exclusion of confirmed malaria cases. Data retrieved from routine information systems in Guinea and Senegal.

FIGURE 4. Breakdown of all-cause outpatient consults into confirmed malaria cases (blue), patients testing negative for malaria (green), and non-tested patients (red) for four districts with poor apparent malaria testing practices: Siguiri in Guinea, and Kebemer, Keur Momar Sarr, and Tambacounda in Senegal. Dashed line represents the crude fever testing proportion, defined as the proportion of all-cause outpatients tested for malaria, and solid line indicates corrected fever testing proportion indicator, defined as the proportion of all-cause outpatients tested after exclusion of confirmed malaria cases. Data retrieved from routine information systems in Guinea and Senegal.

transmission and reports very few malaria cases, the corrected fever testing proportion was relatively stable, with a slight increase during transmission season, but was markedly low throughout the year. There was a peak in non-tested patients in September through November, coinciding with the transmission season, suggesting that there may have been a substantial number of undiagnosed malaria cases. In the Kebemer District, just to the west of Keur Momar Sarr, there was even less of a seasonal increase in malaria testing, with the corrected fever testing proportion remaining extremely low throughout the year. Although very few malaria cases were reported, the low testing rate may have resulted in a number of missed cases.

The corrected fever testing proportion provided more resolution between districts in Guinea (Figure 5). Generally, the crude fever testing proportion was potentially biased for districts with higher transmission. For example, the Ratoma district, one of five districts comprising Guinea's low-transmission capital city, ranked 11th of 38 districts according to the crude fever testing proportion, but first when assessed using the corrected fever testing proportion indicator. Conversely, the Dabola district, one of the highest-incidence districts in Guinea, had the highest crude fever testing proportion in the country, but ranked 16th of 38 when evaluated on the corrected fever testing proportion.

DISCUSSION

Although effective malaria case management requires testing of all febrile patients upon care seeking, routine health systems lack the data elements to monitor this important indicator, and testing rates reported by health facilities cannot be relied on to provide an informative measure of the true

FIGURE 5. The relationship between the crude fever testing proportion, defined as the proportion of all-cause outpatients tested for malaria, and the corrected fever testing proportion, defined as the proportion of all-cause outpatients tested after exclusion of confirmed malaria cases, for 2015 for each of Guinea's 38 districts. The five districts comprising low-transmission Conakry are marked in blue, and high-transmission Dabola is marked in red.

testing rate. Health facility-based surveys assessing health-care provider performance have demonstrated that providers do not consistently assess for febrile illness, and the proportion of patient visits determined by health-care providers to be associated with febrile illness (and therefore, suspected malaria) is consistently an underestimate. Our review of health facility-based surveys with rigorous febrile illness screening suggests that in sub-Saharan Africa, the proportion of patients with febrile illness is consistently greater than 50%, with the proportion of consultations associated with febrile illness generally ranging 70–90% for children younger than 5 years and 50–70% for patients 5 years and older, depending on malaria transmission intensity. Calculating a corrected fever proportion by removing malaria cases gives a narrower range, with most values ranging approximately 60–70% for children younger than 5 years, 40–50% for patients 5 years and older, and 50–60% for all ages included. Although the proportion of all patient visits associated with febrile illness was correlated with the proportion with malaria infection, the corrected testing proportion was not, suggesting a robust and stable rate of non-malaria febrile illness independent of malaria transmission.

In the context of universal testing of all patients with febrile illness, it follows that if one excludes confirmed malaria cases, approximately half of the outpatients attending health facilities should be tested for malaria and found to be negative, with this proportion being higher in young children, in whom a large number of other infections may cause fever. However, calculation of the corrected fever testing proportion, using data elements routinely collected by the health information system (number of all-cause consultations, patients tested for malaria, and patients with positive test results), demonstrates that malaria-endemic countries in sub-Saharan Africa are still far from reaching universal testing of suspect malaria cases seeking care. Our analysis of data from the routine information systems in Guinea, Senegal, and country data reported to the WHO suggests that few malaria-endemic health systems are testing at the level one would expect based on the estimates of the burden of febrile illness from the health facility surveys. This confirms modeling exercises from household surveys that estimate that most acute malaria cases in sub-Saharan Africa are still not being tested or treated appropriately.²⁵ Data from household cross-sectional surveys conducted in 2013–2015 in sub-Saharan Africa showed that 54% of children younger than 5 years with fever in the previous 2 weeks sought care from a trained provider and 31% received a malaria test.¹⁷ Although cross-sectional surveys do not generally measure these indicators for those aged 5 years and older, care seeking and testing is thought to be lower in this age group. Some districts in both Senegal and Guinea demonstrated notable deficiencies in testing practices, each deviating from the expected testing practice in its own way. Some demonstrated large increases in untested patients coinciding exactly with malaria transmission season, possibly indicating a large number of missed malaria cases. Some demonstrated remarkably low corrected testing rates during the dry season compared with rainy season, whereas others had very low corrected testing proportions all year.

Nevertheless, we found that there are a few districts in both Guinea and Senegal that consistently test near the expected level. In both Guinea and Senegal, there is great between-district heterogeneity, with certain districts' corrected fever

testing proportion up to 7-fold higher than their neighboring districts. Because many of the factors influencing the quality of malaria case management such as trainings, supervision, and availability of commodities operate at the district level, this result is not unexpected. Moreover, it provides evidence that sufficient testing rates can likely be achieved with existing training strategies and supply chain management. In fact, the east–west gradient in corrected fever testing proportion in Guinea may reflect a scenario in which case management strengthening efforts were more readily adopted in the west of the country, with their implementation becoming more difficult and delayed with increasing distance away from the coastal capital.

By contrast, regional differences in Senegal are more likely reflective of the gradient in malaria transmission between the low-incidence north and the remaining zones of high malaria transmission in the southeast, as well as the profound seasonality of transmission, with lower corrected fever testing proportions in the north and during dry season. Consistently low rates of malaria test positivity among febrile patients may discourage health-care workers from universal testing of all fever cases, who might be factoring in a pre-test probability when deciding whether to test for malaria. Longitudinal trends in Senegal also need to be interpreted in the context of changing guidelines for malaria testing. Senegal introduced RDTs in 2007 with a recommendation that only patients without an alternate fever source receive an RDT; those with signs and symptoms consistent with a non-malaria febrile illness were to be treated for that illness. An RDT was recommended if they returned without fever resolution. An evaluation conducted in 2013–2014 found that this approach missed an unacceptably high proportion of malaria cases, particularly among children younger than 5 years.²⁶ As a result, in June 2014, the NMCP issued guidance to test all febrile children younger than 5 years throughout the year, expanding to include all febrile patients older than 5 years during rainy season in 2015, and all febrile patients regardless of age or transmission season in mid-2017. Although the crude testing proportion appears to have plateaued since 2015 indicating no increase in testing, the steady increase in the corrected testing proportion suggests that, in fact, testing practices have continued to improve. The improvement in corrected testing proportion with the introduction and extension of the policy of universal testing of febrile illness, first to children younger than 5 years, and subsequently to older patients, demonstrates that although much improvement is still needed, providers appear to have changed their behavior in response to national directives. This observation only becomes apparent following analysis of the corrected testing proportion, with the crude testing proportion masking this trend because of the confounding of decreasing malaria burden.

The finding that likely less than half of febrile outpatients are tested for malaria in sub-Saharan Africa has several profound consequences, including suboptimal care of patients who might be sent home untreated with a potentially deadly disease, and an adverse impact on overall malaria control efforts and surveillance systems meant to provide valid trends. A recent modeling study suggested that in low-transmission settings, if importation can be limited, correct testing and treatment of all malaria cases presenting to health facilities is likely to result in elimination of malaria without introducing any

additional strategies such as mass test-and-treat or mass drug administration.²⁷ However, the apparent decrease in testing for malaria in contexts of low transmission (either during the dry season or in low-transmission districts) is worrisome for prospects of elimination. If health-care providers are less likely to test patients with febrile illness for malaria where risk is perceived to be low, patients with malaria infection will be missed, resulting in a missed opportunity to treat infections and prevent onward transmission, as well as potentially dangerous consequences in contexts in which individuals have lost immunity to malaria. Monitoring the proportion of patients with febrile illness tested for malaria is as important in low- as in high-transmission settings.

Although many malaria control programs monitor the proportion of all suspect cases that receive a diagnostic test, these are often inflated, and although some monitor the proportion of all consultations that receive a diagnostic test, this varies with malaria burden. As seen in Senegal, crude testing proportion may mask improvement in testing practices as the proportion of malaria fevers (and thus, all febrile illnesses) declines. By contrast, the corrected fever testing proportion, which can also be calculated using routinely collected data elements, could be used to assess districts of varying malaria transmission intensity on appropriate testing practices and identify potential gaps in testing that can be addressed by program managers and supervisors.

However, there are a number of nuances that will inevitably be missed by looking only at routine data. For example, analysis of aggregate data can only give an indication of whether roughly enough testing is taking place, but cannot indicate whether the appropriate patients are being tested. Only a health facility survey that looks at individual-level patient data can properly evaluate malaria case management practices. Second, without data on availability of malaria commodities, analysis of routine health facility data cannot distinguish between poor health-care worker practices and scarcity or stock-outs of malaria tests as the primary driver of low testing rates. Finally, outbreaks or seasonal fluctuations of non-malaria illness, such as typhoid fever, arboviruses, influenza, or other common infectious diseases, can violate the assumption of a steady rate of non-malaria febrile illness and can make interpretation of the corrected fever testing proportion difficult. Nevertheless, outbreaks of febrile illness would increase the number of febrile patients seeking care, meaning that the corrected fever testing proportion should be even higher than 50%.

Regardless of the level of malaria transmission, more effort is needed to encourage higher testing rates in health facilities. In the absence of good quality data on true fever rates, programs should consider evaluating health facility testing practices based not on the reported testing rate among reported suspect cases or testing rate among reported all-cause visits, but rather the corrected fever testing proportion. Malaria control programs could consider targeting a minimum corrected testing proportion for health facilities of 50% in areas endemic for malaria. There is often pressure for health facilities to achieve low incidence, or not to “waste” RDTs; Ministries of Health should consider instead incentivizing health facilities to increase their proportion of negative malaria tests. As malaria testing continues to increase and malaria burden decrease, the number of negative malaria tests should be expected, and encouraged, to increase over time.

Most health facility assessments that evaluate malaria case management practices include patients already determined to be febrile; few determine the proportion of patient consultations associated with febrile illness, and the proportion of these that are identified and tested by health-care workers. This early step in the case management pathway is critical to include in future health facility assessments of quality of case management to understand the true proportions both of patients with febrile illness and missed symptomatic malaria infections.

Adopting a policy of monitoring and enforcing universal diagnostic testing of fever would have implications for health systems and malaria program management. Incomplete testing of fever cases is likely not due solely to provider choice; this may be driven in part by scarcity of RDTs and consequent RDT rationing even without reported stock-outs, when stocks become low or re-supply is infrequent and/or insufficient. In 2015, 240 million RDTs (at a cost of \$65 million) were procured and delivered to sub-Saharan Africa,¹⁷ which now has a population just over one billion. Scale-up of universal malaria testing of fever cases would mean that the number of RDTs would need to increase several-fold. Beyond quantification and procurement, moving this quantity of commodities would require additional resources in the supply chain. At point of care, even with RDTs, health facilities will require additional human resources to ensure that all febrile patients receive a malaria test and results are properly recorded. Although resources may often already be available for supervision and monitoring of quality of case management, detecting and testing all fever cases will need greater emphasis.

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