The Unmet Need: Low Performance of Laboratory Professionals in Malaria Microscopy, Oromia Regional State, Ethiopia

Sagni Challi,^{1*} Hirpa Miecha,² Demekech Damtie,¹ Girma Shumie,¹ Wakweya Chali,¹ Tsegaye Hailu,¹ Taye Tolera Balcha,¹ Fitsum G. Tadesse,^{1,3,4} and Endalamaw Gadisa¹

¹Malaria and Neglected Tropical Diseases Research Directorate, Armauer Hansen Research Institute, Addis Ababa, Ethiopia; ²Oromia Regional Health Bureau, Addis Ababa, Ethiopia; ³Institute of Biotechnology, Addis Ababa University, Addis Ababa, Ethiopia; ⁴Department of Medical Microbiology, Radboud University Medical Center, Nijmegen, The Netherlands

Abstract. Ethiopia aims to diagnose and treat all clinical malaria within 24 hours of fever onset in its stride to eliminate the disease by 2030. Microscopy remains to be the mainstay for diagnosis at the health center and hospital level. Continuous evaluation and performance upgrading of malaria microscopists is one of the cornerstones in this effort. We assessed the performance of malaria microscopists compared with reference readers in diagnosing, identifying the species, and quantifying parasitemia. A total of 174 microscopists were enrolled from health facilities located in 86 districts in Oromia region (Ethiopia) from January 2017 to June 2018. Panel slides with known *Plasmodium* species, diagnostic blood stage, and parasite density were prepared by the reference readers. Sociodemographics, education, in-service training, and routine practice of participants were captured. Sensitivity, specificity, percent agreement, and kappa score were calculated. An overall low performance was observed that could threaten the malaria diagnostic service. Of all the slides distributed (1,218), only 17.0% of the positive and 30.0% of the negative slides were correctly identified and 22.4% were correctly quantified. Compared with the reference readers, participants had lower competence in diagnosing (74.3% agreement and kappa 0.45) and identifying the species (71.2% agreement and kappa 0.40). Two-fifths of the participants were graded as “in training” with respect to identifying the species (41.0%) and the diagnostic stages (40.0%). An in-service training/retraining and supportive supervision are needed to raise and maintain the competence of microscopists in settings with a recent decline in malaria transmission and aiming for ultimate elimination of the disease.

INTRODUCTION

Despite the substantial decline in morbidity and mortality attributed to malaria in the last two and half decades, malaria still remains a disease of major public health relevance. A shift in the trend of global malaria burden, mainly from highly endemic African settings, has been reported in the last 3 years compared with the years before.¹ Of the 219 million cases and 435,000 deaths recorded in 2017, most of the cases (92%) and deaths (93%) are reported from the WHO Africa region. By contrast, Ethiopia succeeded in further cutting the malaria burden and is on track to meet the 2020 target, 40% reduction from its baseline in 2010.¹

Building on the success in the past decade, Ethiopia embarked on a stepwise approach to eliminate malaria by 2030. The national malaria control program defined a target to diagnose and treat all suspected cases within 24 hours of fever onset. Unique to most settings in Africa, differential diagnosis is required in Ethiopia to initiate treatment for either of the two predominant species causing clinical malaria, *P. vivax* (40%) and *P. falciparum* (60%).² Malaria transmission and distribution of the two species is heterogenous both spatially and temporally in Ethiopia. Despite the very low overall prevalence of malaria, 60% of the population lives in malaria-prone areas, of which most are low endemic and approaching for elimination and few (6.4%) have high transmission.³ This underlies the need to strengthen the program. Multispecies rapid diagnostic tests (RDTs) are recommended at the health post level (the lowest health service providing institution), and microscopy is practiced at the health center and hospital levels.

The national guideline defined external quality assessment and continuous gap filling in-service training as one of the cornerstones in the stride to meet the 2030 target.² In the present study, the performance of laboratory professionals on the detection and identification of *Plasmodium* species and quantification of the parasitemia was evaluated in medium to high malaria transmission districts in Oromia regional state, Ethiopia.

METHODS AND MATERIALS

Study design and area. A facility-based cross-sectional study was conducted from January 2017 to June 2018 in medium and high malaria transmission districts with ongoing malaria transmission³ in Oromia regional state, Ethiopia. The country's malaria risk strata are based on malaria annual parasite incidence, whereby areas are classified as high transmission (≥ 100 cases/1,000 population/year), moderate (≥ 5 –100), low (0–5), and malaria free (~ 0).³ Malaria microscopists who were trained in laboratory technology programs and available at the time of the study from 169 health facilities that were located in 86 districts were enrolled in the study.

Panel slide characteristics. Multiple sets of panel slides were prepared and double-read by two WHO-trained and competence level-1⁴ certified malaria microscopists based on the predominate species causing clinical malaria: *P. falciparum*, *P. vivax*, and mixed infection with *P. falciparum* and *P. vivax*. A panel of 10 slides that consisted of seven slides with different parasite densities—two low density (1–10 parasites per 100 thick film oil immersion fields), two medium (11–100 parasites per 100 fields), and three high (1–10 parasites per one thick film field)—and three negative slides were prepared so that the results of the evaluation could be compared between the participating laboratories. The slide panel was packed in sets in slide boxes and distributed to the

* Address correspondence to Sagni Challi, Malaria and Neglected Tropical Disease Research Directorate, Armauer Hansen Research Institute, Jimma Rd., P.O. Box 1005, Addis Ababa 1005, Ethiopia. E-mail: sagni_challi@yahoo.com

participant health facility, accompanied by a questionnaire, reporting forms, and instruction sheets that were packed separately. The instruction sheet detailed that the participant spend 10 minutes per slide, and slide examination should be performed individually and in 2 days, whereby randomly selected five slides of the panel were instructed to be examined on each day. Slide quality was assessed after use and before distribution to the next health facility. Panel slides were double-read by two WHO-certified malaria microscopists.

Data collection and management. A pretested semi-structured questionnaire was used to capture information about the participating health facilities and microscopists. Sociodemographics, educational background, service years, and the routine practice and training (in-service) of the study participants were collected. Availability and condition of the microscope, and level of the health facility were also recorded. Data collectors were trained and maximum effort was made to simulate routine functions by avoiding intensive supervision during slide reading. The microscopists were requested to interpret each slide toward three diagnostic keys at the end of the examination: score the presence/absence of diagnostic blood stage, identify the infecting *Plasmodium* species and the specific diagnostic blood stage, and count the parasite load for each parasite species and classify as low, medium, or high.

Statistical analysis. Data were double-entered using REDCap software (Vanderbilt University). Cleaned data were analyzed using SPSS for Windows version 20 (IBM Corp., Armonk, NY). Level of performance in detecting, identifying the species and the diagnostic blood stages of *Plasmodium* species, and quantifying using light microscopy was compared. Sensitivity, specificity, the proportion of errors, percent agreement, and kappa score were calculated, and $P < 0.05$ was considered statistically significant.

Ethical clearance. The study was approved by the institutional ethics review board of the Armauer Hansen Research Institute (P016/17, May 17, 2017). An official letter was sought from Oromia Health Bureau (BEFO/AHBTR/1-8/2759, June 5, 2017). Informed written consent was obtained from each participant. Data were anonymized, summarized, and interpreted in aggregate.

RESULT

Sociodemographic characteristics of the study participants. A total of 174 laboratory professionals, mean age 28 (± 3.2) years, mostly male (124, 71.3%), participated in the study. With respect to their level of education, 103 (59.2%) had diploma, 55 (31.6%) had generic Bachelor of Science (joined the training program on completion of their high school studies) and 16 (9.2%) had post-basic Bachelor of Science (joined the training program after few years of service with a diploma) certificates. The majority had more than 2 years of experience (141, 81.0%) and received malaria microscopy training course (113, 64.9%) during their practice.

Routine practices of participants. More than half of the participants (61.0%, 106/174) reported that they examined more than five blood film slides per day. Whereas 145 (83.3%) of the participants reported that they used both thick and thin blood films, 28 (16.1%) used only thick films. Almost all reported that their microscope is functional (97.7%, 170/174)

and there was no supportive supervision during their service years (98, 56.7%), neither from the regional nor the national level. Apart from microscopy, 34 (11%) participants reported that they used a RDT to diagnose malaria.

Performance in diagnosing malaria infection. The overall performance of the participants in diagnosing malaria was low (Table 1). Very few participants (5/174, 2.9%) correctly read all the 10 panel slides as proficiency testing. Of the 174 participants, 21 (12.1%) missed at least one slide, 29 (16.7%) correctly reported all seven positive slides as positive, and 52 (29.9%) correctly reported all three negative slides as negative.

Competency in diagnosing, quantifying parasitemia, and identifying species. Compared with the reference readers, the sensitivity (69.7%) and specificity (80.4%) of participants in diagnosing malaria were low (agreement 74.5%, kappa 0.45). The performance was better at hospitals than health centers (Supplemental Table 1). In terms of quantifying the parasitemia, of 1,218 slides distributed, 630 (51.7%) were attempted and 273 (43.3%) of them were correctly quantified. The overall competence of the laboratory professionals compared with the reference readers was lower in correct identification of malaria species: agreement 71.2% and kappa 0.4. Looking across institutions, the performance was better at hospitals (agreement = 74.1%, kappa 0.64) than health centers (agreement = 73%, kappa 0.51) (Supplemental Table 2).

Classification of participant performance based on WHO classification. When evaluated according to the WHO grading system which is detailed in the technical consultation proposed by WHO,⁴ 40.8% (71/174) were rated as “in training” and 16.7% (29/174) reached agreement on an expert level with respect to species identification. Regarding stage identification, 40.2% (70/174) were rated as “in training” and 9.8% (17/174) reached agreement with an expert. On the performance of parasite quantification, 84.5% (147/174) were rated as “in training” and 4.0% (7/174) reached agreement with an expert (Supplemental Table 3).

TABLE 1

Performance of laboratory professionals ($N = 174$) in diagnosing malaria infection

Slide panels	Number (%)
All ten slides correctly reported	5 (3)
One slide missed	21 (12)
Two slides missed	28 (16)
Three slides missed	46 (26)
Four slides missed	29 (17)
Five slides missed	14 (8)
Six slides missed	10 (6)
More than seven missed	21 (12)
Positive slides ($N = 7$)	
All positive slides correctly reported	29 (17)
Only one positive slide missed	33 (19)
Two positive slides missed	48 (28)
Three positive slides missed	31 (18)
More than three positive slides missed	25 (14)
All positive slides missed	8 (4)
Negative slides ($N = 3$)	
All negative slides correctly reported	52 (30)
One negative slide missed	55 (32)
Two negative slides missed	33 (19)
All negative slides missed	34 (20)

DISCUSSION

Malaria continues to be among the top ten diseases of public health importance in Ethiopia despite decades of successful implementation of control measures.² To accelerate its stride toward malaria elimination by 2030, Ethiopia adjusted its malaria diagnosis policy whereby Giemsa-stained thick and thin blood films are the standard at hospital and health center levels. To achieve its goal of treating all cases within 24 hours of onset of fever,⁵ the need for continuous monitoring and gap-filling in-service training must be addressed. In the present study, we assessed the performance of malaria microscopists in 169 endemic districts of Oromia regional state by distributing panel slides prepared by reference readers, which showed an overall low competence.

Of the 174 participants, only 16.7% (29) and 29.9% (52) read all the positive and negative slides correctly, respectively. The sensitivity (69.7%) and specificity (80.4%) in correct diagnosis compared with those of the reference readers had only a moderate agreement (agreement 74.5%, kappa 0.45). These findings are comparable with reports from Gondar (North-western Ethiopia),⁶ Addis Ababa and its surroundings,⁷ Tigray (Northern Ethiopia),⁸ and Western Ethiopia.⁹ But the performance and competence of participants in the present study were lower than those reported from Hawassa (South Ethiopia)¹⁰ and Bahir Dar city (Western Ethiopia).¹¹ The relatively higher malaria endemicity in Hawassa and Bahir Dar partly explains the higher performance reported in these studies on malaria diagnosis. On top of that, most of the participants in the previous studies had longer experience in slide reading than participants in the present study.

The very low sensitivity in detection of malaria parasites found in this study is alarming; 211 (37.4%), 146 (29.6%), and 12 (7.4%) blood film slides with *P. falciparum*, *P. vivax*, and mixed infection, respectively, were identified wrongly as negative. The staggering false-negative reports could contribute not only to delayed treatment, which in turn means pronounced onward malaria transmission, but also more importantly to the development of serious complications and death and unintended exposure to other medications.

In the current study, better agreement (agreement 71.2%, kappa 0.4) was found in microscopists identifying the malaria species than reference readers. This was comparable with the report from Gondar, better than the report from Addis Ababa and its surroundings, and lower than those from Bahir Dar, Hawassa town, and Tigray.^{7–11} Taken together, two-fifths of the participants were rated as “in training” based on WHO recommendation, which is better than the rating of microscopists from Hawassa town¹⁰ and lower than that of participants from Addis Ababa.⁷ Only a quarter of the slides were correctly quantified in this study, which is much lower than findings from Bahir Dar.¹¹ The most plausible explanation for the variations observed between the current study and previous reports inclines toward malaria endemicity, which in turn leads to limited practice in providing routine malaria diagnostic service. Apart from this, the likelihood to maintain and develop skills on malaria parasite detection, identification, and quantification can be enhanced with regular supportive supervisions. In-service training and supportive supervision were, however, not implemented in the current study and the studies reported previously.

For low-resource settings, the importance of rigorous performance monitoring is more emphasized than repeated standard trainings.^{12,13} To this end, Ethiopia uses a network of regional laboratories led by the national public health institute for laboratory capacity building. Yet, maintaining quality malaria microscopy was not achieved as demonstrated by the present study and others.^{8–11,14,15} This underlines that Ethiopia might need to embark on a large-scale comprehensive quality assurance scheme on top of deployment of a large workforce of microscopists and fulfilling minimal infrastructure need, to accelerate the stride toward malaria elimination. On the other hand, studies in Ethiopia demonstrated the equivalent performance of RDTs compared with microscopy, which has less technical difficulties.^{16–18} After the deployment of RDTs in 2005, case detection has improved substantially in Ethiopia from < 20% before 2008 to ~40% in 2012 and > 80% since 2013.²

It is common practice that laboratory technologists, not especially trained for slide reading, could participate in routine diagnostics in circumstances when there is shortage of trained staff. This study has enrolled only microscopists assigned for malaria diagnosis and who were available at the time of visit. Including other laboratory technologists who could potentially participate in random slide reading would help capture more information on the real-life experience. The comparison in the present study solely relied on the competency of the certified experts. Molecular confirmation of parasite species and quantification of parasites with highly sensitive and accurate techniques would improve comparison of future findings. Overall, the laboratory professionals in the current study sites had low performance in the detection, species identification, and quantification of parasitemia. In-service training/retraining to raise and maintain their performance is crucial on top of supportive supervision and schemes to mitigate attrition to maintain staff on service for longer periods. As Ethiopia aims to embark on phased malaria elimination, it might be wise to maximize diagnostic capabilities. We recommend a careful system and capacity appraisal before policy shift to restrict RDT use only at the health post level. We see the need for alternative use of RDTs for better programmatic performance.

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Authors' addresses: Sagni Chali, Demekech Damtie, Girma Shumie, Wakweya Chali, Tsegaye Hailu, Taye Tolera Balcha, Fitsum G. Tadesse, and Endalamaw Gadisa, Malaria and Neglected Tropical Diseases Research Directorate, Armauer Hansen Research Institute, Addis Ababa, Ethiopia, E-mails: sagni_challi@yahoo.com, demekech@gmail.com, shumiegirma@gmail.com, wakeyachali@gmail.com, tsegsha2@gmail.com, tayetolera@yahoo.com, fitsezemichael@gmail.com, and gadisa.endalamaw@gmail.com. Hirpa Miecha, Oromia Regional Health Bureau, Addis Ababa, Ethiopia, E-mail: mirayeshma@gmail.com.

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