

Research Article

Competence of Laboratory Practitioners on Malaria Microscopy and Associated Factors in Moshi Municipality, North-eastern Tanzania

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Abstract

Accurate detection and confirmation of malaria parasites require good-quality microscopy. Low-quality microscopy can result in incorrect diagnoses and, hence, ineffective treatments. Several factors, including the skills of laboratory personnel, influence the quality of malaria microscopy, posing challenges in malaria diagnosis. The present study assessed the competence of medical laboratory practitioners in malaria microscopy and associated factors in selected health facilities in Moshi Municipality, Tanzania. A cross-sectional study was conducted from May to June 2024, where 147 laboratory practitioners from 45 health facilities in Moshi Municipality were included in the study. Six standardized External Quality Assessment malaria slides were distributed to each health facility. Individual laboratory practitioners in each facility had a choice to read only one of the slides. The competence of laboratory practitioners in malaria microscopy in this study was measured by the accuracy of detection and quantification of malaria parasites. Multiple logistic regression was performed to determine factors associated with good performance in malaria microscopy, where the odds ratio (OR) and corresponding 95% confidence interval were reported. All variables with p-values <0.05 were considered significant. A total of 147 laboratory practitioners participated, and the accuracy of malaria parasite detection and quantification was 46.2% and 36%, respectively. Malaria microscopy training showed an association with the accuracy of malaria slide reading with COR=3.437 (CI=1.681-7.031), p-value=0.001, AOR=2.669 (CI=1.217-5.855), p-value=0.014. Our study results show a low level of proficiency in malaria microscopy among laboratory practitioners in Moshi Municipality. Our study results show a low level of proficiency in malaria microscopy among laboratory practitioners in Moshi Municipality. Refresher training in malaria microscopy could improve the performance of the laboratory practitioners for the detection and quantification of malaria parasites.

Keywords

External Quality Assessment, Malaria, Malaria Microscopy, Competence, Laboratory Practitioners, Moshi Municipality, Tanzania

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Received: 30 June 2025; **Accepted:** 14 July 2025; **Published:** 30 July 2025



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1. Introduction

Malaria is a life-threatening, preventable, and curable disease spread to humans by mosquitoes, mainly found in tropical countries. Symptoms can be mild or life-threatening. Mild symptoms are fever, chills, and headache. Severe symptoms include fatigue, confusion, seizures, and difficulty breathing. Infants, children under five years, pregnant women, travelers, and people with HIV/AIDS are at higher risk of severe infection [1]. The accurate diagnosis of malaria, which is very important in the monitoring and control of the disease, depends on two key test methods, where mRDT acts as the screening test and blood slide microscopy acts as confirmatory or the gold standard [2].

According to the World Malaria Report of 2022 [3], malaria remains a significant public health concern, particularly in regions where it is endemic. Globally, there were an estimated 249 million cases and 608,000 malaria deaths in 85 countries in 2022 [3]. The Sub-Saharan African region carries a high African malaria burden, with 94% of cases and 95% of deaths. Children under 5 years of age accounted for about 78% of malaria deaths in the region [1]. Four African countries accounted for just over half of all malaria deaths worldwide. The countries are Nigeria at 26.8%, DRC at 12%, Uganda at 5% and Mozambique at 4.2 percent [1]. Tanzania contributes to 3% of the malaria burden in malaria-endemic regions and contributes to the highest global malaria deaths of 5 percent [4].

The high performance of malaria microscopy for diagnosing malaria determines the effectiveness of disease control and ways to overcome this deadly disease [5]. An effective quality assurance (QA) system is needed for quality malaria microscopy, involving standardization of procedures and establishment of national-level diagnostics centers responsible for developing training modules, conducting training, identifying the materials needed to support microscopy, QA, improving the performance, and maintaining the competence of microscopists [6, 7].

Internal quality assurance (QA) for malaria microscopy is a system that helps improve the accuracy and efficiency of malaria diagnosis, ensuring that malaria microscopy procedures are performed consistently across laboratories. External quality assessment (EQA) refers to a system where a reference laboratory sends out standardized blood slides with known malaria parasite levels to participating laboratories, allowing them to assess their microscopy skills.

This ensures that their results are compared to the known correct answers, thus identifying areas for improvement and ensuring the quality of malaria diagnosis across different facilities; essentially acting as a quality control check for malaria microscopy practices. EQA is among the effective methods for evaluating the quality of malaria microscopy for malaria diagnosis [8-12].

If we fall short of upholding this, the outcome can be a misdiagnosis of malaria due to species misidentification, and

patients can be subjected to wrong and inappropriate treatment. [13] Misdiagnosis has been documented elsewhere including Tanzania [14, 15] and Uganda [16]. Other negative consequences that result from the low accuracy of routine microscopy are waste of limited resources, increased costs for treatment, unnecessary exposure of patients to the adverse effects of drugs, and chiefly the fact that clinicians tend to overlook other causes of febrile illness [17, 18]. Inadequate skills in identifying and ruling out malaria parasites may lead to misdiagnoses, inappropriate treatment, and a delay in initiating proper [5].

Several factors contribute to the complexity of this problem, including the dynamic nature of malaria parasites that requires a high level of expertise in distinguishing them from other blood components accurately [19]. Variations in the training backgrounds of health workers may lead to discrepancies in their skills and competencies [20], and availability and utilization of resources such as quality microscopes and staining reagents that may influence the effectiveness of microscopic examinations [21].

In the fight against this deadly disease, the good performance of microscopic examination of blood smears and compliance with national guidelines for malaria diagnosis remains a fundamental diagnostic strategy because microscopic examination of stained blood film has high sensitivity and specificity when used by well-trained laboratory practitioners with the possibility of detecting as low as 50 parasites/uL.

Other advantages of blood film microscopy include the determination of malaria parasite densities, the distinction between parasite stages, and differentiation between malaria species, and the diagnosis of other blood-borne parasitic diseases [22]. The competence of laboratory practitioners in utilizing microscopic procedures to rule out malaria parasites and their familiarity with national guidelines for malaria diagnosis are both critical aspects that directly impact the good performance and efficiency of diagnosis [5].

Moreover, considering the improved healthcare delivery, it is crucial to align the skills of health workers with current best practices and technological advancements in malaria diagnosis. Understanding the challenges faced by health workers in Moshi Municipality will not only help identify specific areas that require targeted training but will also contribute to the development of tailored interventions aimed at improving the overall quality of malaria diagnosis.

Therefore, this study provides valuable insights into the existing gaps in the performance of microscopic techniques for malaria diagnosis and factors influencing good performance among laboratory practitioners in Moshi Municipality. Our study report paves the way for creating strategies to enhance the accuracy of laboratory practitioners in routine malaria microscopy. Addressing these aspects will contribute to

the accuracy of malaria diagnoses, better patient outcomes, and overall effectiveness of malaria control programs in Moshi Municipality.

2. Materials and Methods

2.1. Study Design and Setting

This study was a cross-sectional study designed to evaluate accuracy and factors influencing the competence of laboratory practitioners in malaria microscopy in Moshi Municipality. This study was conducted in Moshi Municipality (3°20'34.8"S 37°21'2.52"E), a district located in Kilimanjaro region north eastern Tanzania. Moshi Municipality is an urban area with low malaria transmission. The Moshi Municipality has a diverse population and several healthcare facilities offering diagnostic services for malaria.

2.2. Study Population

The study population consisted of 147 laboratory practitioners from 45 facilities who were directly involved in malaria diagnosis. Inclusion criteria were laboratory practitioners working in the selected healthy facility who are directly involved in microscopic malaria diagnosis. A convenience sampling method was used in choosing the facilities and laboratory practitioners to be assessed. The study-dependent variable was the competence of laboratory practitioners in malaria microscopy measured by the accuracy of detection and quantification of malaria parasites.

The independent variables were age, gender, training, participation in EQA and implementation of IQA schemes, facility levels, license status level of education, and duration of working experience.

2.3. Data Collection

Laboratory practitioners from the selected facilities were provided with questionnaires before microscopic procedures of malaria diagnosis. Then EQA EQA-stained blood smear slides were provided to laboratory practitioners who were involved in the study. A total of 6 slides were used, 3 had no malaria parasite and the other 3 had malaria parasites in different densities i.e. high, moderate, and low parasite densities. The EQA blood slides were obtained from KCMC hospital where they were part of an EQA scheme from the national laboratory. The EQA slides were given to the laboratory practitioners for examination where individual laboratory practitioners in each facility had a choice to read only one of the slides then the results of the practitioners were compared with the known results of the EQA slides. A checklist of procedures was used to observe as the practitioner examined the EQA slides microscopically and the results were recorded for comparison with the known results of the EQA slides.

An acceptable range was set of which the practitioner was judged to pass or fail. During data collection, the questionnaire was used to obtain data on factors associated with malaria microscopy competence.

2.4. Data Management and Analysis

Data was entered, cleaned, and checked for quality assurance and consistency. The missing values and duplicates were reported and corrected. Variables were clearly labeled and coded including categorical variables that were identified and coded efficiently as per their levels based on previous literature for better interpretation and comparability. A checklist was created and used to organize data in an orderly function. Analysis was carried out using SPSS (Statistical Package for the Social Science) version 25. Descriptive statistics was for categorical that was summarized in tables. Numerical variables were summarized using mean and standard deviations.

Multiple logistic regression was performed to determine factors associated with good performance in malaria microscopy, where by odds ratio (OR) and corresponding 95% confidence interval were reported and all variables with p-value <0.05 were considered significant.

3. Results

3.1. Demographic Characteristics of Laboratory Practitioners in Moshi Municipality

A total of 147 participants from 45 health facilities participated in this study. The mean age of the study participants was 30.9 years and the majority were males (58.5%). The majority of the participants (28%) were working at the dispensaries and 57% of the participants were diploma holders (Table 1).

Table 1. Demographic characteristics of laboratory practitioners in Moshi Municipality (n=147).

Variable	Frequency	Percentage
Age	30.9 (6.90)	
18-30 years	91	61.9
31-40 years	38	25.9
41 years-Above	18	12.2
Sex		
Male	86	58.5
Female	61	41.5
Facility level		
Dispensary	42	28.6
Health center	37	25.2

Variable	Frequency	Percentage
Polyclinic	23	15.6
Private laboratory	8	5.4
Hospital	37	25.2
Education level		
Certificate	31	21.1
Diploma	83	56.5
Advanced diploma	4	2.7
Bachelor	29	19.7

3.2. Malaria Microscopy Competence Among Laboratory Practitioners in Moshi Municipality

Out of 147 participants, only 45 participants (30.6%) were able to detect the slides with the malaria parasites while 23 participants (15.6%) detected accurately slides with no malaria parasites, hence the accuracy measure of 46.2% on detection of malaria parasites. Of 147 participants, 30 participants (20.4%) were able to quantify malaria parasites on the slides with malaria parasites and 23 participants (15.6%) were able to malaria parasites on slides with no malaria parasites and this brought the accuracy measure of 36% on quantification of malaria parasites (Table 2).

Table 2. Competence of laboratory practitioners based on detection and quantification of malaria parasites in Moshi Municipality.

Practitioners slide report	EQA slide stats		Total
	EQA slides with parasites	EQA slides with no parasites	
Detected	45	23	68
Not detected	36	43	79
Total	81	66	147
Quantified	30	23	53
Not quantified	50	44	94
Total	80	67	147

EQA=External Quality Assurance

3.3. Overall Performance of Laboratory Practitioners in Malaria Microscopy at Different Health Facilities Levels in Moshi

The overall performance of different health facilities is summarized in Figure 1. The highest performance was shown by private laboratories (62.5%), followed by hospitals (59.5%). The lowest performance was shown by the health centers (40.5%).

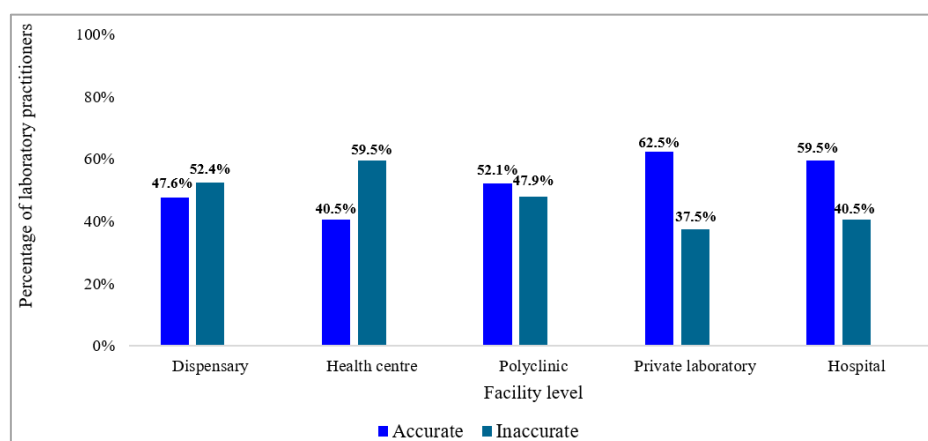


Figure 1. Overall performance of laboratory practitioners in malaria microscopy at different health facilities levels.

3.4. Factors Influencing Competence of Laboratory Practitioners in Malaria Microscopy in Moshi Municipality

HLPC registration, working duration, EQA enrolment, awareness of national guidelines for malaria diagnosis, and level of education were associated with malaria microscopy

competence. However, in the adjusted model, only one factor i.e. practitioners' training showed an association with the outcome of this study. Participants with training in malaria microscopy diagnosis had odds two times more in reading the slides accurately compared to those who had no training (AOR=2.669, CI=1.217-5.855) (Table 3).

Table 3. Factors influencing competence of laboratory practitioners in malaria microscopy in Moshi Municipality.

Variable	N	Accurate n (%)	COR (95% C.I)	p-value	AOR (95% CI)	p-value
Age						
18-30 years	91	37 (40.7)	0.475 (0.141-1.599)	0.229		
31-40 years	38	21 (55.3)	0.264 (0.087-0.802)	0.019		
41 years-Above	18	23 (72.2)	1			
Sex						
Male	86	42 (48.8)	1.053 (0.546-2.031)	0.877		
Female	61	29 (47.5)	1			
Facility level						
Dispensary	42	20 (47.6)	1.270 (0.264-6.117)	0.766		
Health center	37	15 (40.5)	0.990 (0.347-2.831)	0.986		
Polyclinic	23	12 (52.1)	0.413 (0.162-1.054)	0.064		
Private laboratory	8	5 (62.5)	0.629 (0.258-1.533)	0.308		
Hospital	37	22 (59.5)	1			
Level of education						
Certificate	31	12 (38.7)	0.933 (0.115-7.553)	0.948		
Diploma	83	42 (50.6)	0.956 (0.410-2.228)	0.917		
Advanced diploma	4	2 (50)	0.589 (0.211-1.645)	0.313		
Bachelor	29	15 (51.7)	1			
HLPC registration						
Yes	118	64 (54.2)	3.725 (1.78-9.388)	0.005		
No	29	7 (24.1)	1			
Working duration						
1 to 5 years	105	45 (42.9)	0.181 (0.020-1.636)	0.128		
5 to 10 years	34	19 (55.9)	0.107 (0.013-0.902)	0.04		
10-More	8	7 (87.5)	1			
Malaria microscopy training						
Yes	93	55 (59.1)	3.437 (1.681-7.031)	0.001	2.669 (1.217-5.855)	0.014
No	84	16 (29.6)	1			
EQA enrolment						
Yes	66	39 (59.1)	2.212 (1.140-4.291)	0.019		

Variable	N	Accurate n (%)	COR (95% C.I)	p-value	AOR (95% CI)	p-value
No	81	32 (39.5)	1			
IQC programme						
Yes	78	41 (52.6)	1.441 (0.751-2.763)	0.272		
No	69	30 (43.5)	1			
Awareness of national guidelines for malaria diagnosis						
Yes	118	66 (55.6)	6.092 (2.175-17.061)	0.001		
No	29	5 (17.2)	1			

N=Number of participants; COR=Crude Odds Ratio; AOR=Adjusted Odds Ratio; CI=Confidence Interval; HPLC= Health Laboratory Practitioners Council; EQA= External Quality Assurance; IQC= Internal Quality Assurance

4. Discussion

The present study aimed to evaluate the competence of laboratory practitioners in malaria microscopy and the factors that influence it in Moshi Municipality. Malaria microscopy remains the most reliable means of confirming positive results by MRDTs and also monitoring patients who have been diagnosed with malaria and are under treatment [5]. The findings of this study show that the competence of laboratory practitioners in Moshi municipality is moderate. Most of the laboratory practitioners at dispensaries and health centers who constitute the majority of participants in this study had a lower level of competence than that of participants from the hospitals, private laboratories, and polyclinics.

In this study, less than fifty percent of laboratory practitioners were able to detect the presence or absence of malaria parasites in EQA slides given, only about one-third of laboratory practitioners were able to correctly quantify the malaria parasites as required per slides. The competence of malaria microscopy is usually associated with several factors including training, participation in EQA and implementation of IQA schemes, facilities levels, license status, level of education, duration of working experience, and awareness of guidelines for malaria diagnosis. In this study, participants with training in malaria microscopy diagnosis had odds two times more to reading the slides accurately compared to those who had no training.

The findings of this study are consistent with earlier studies and suggest that currently, many health facilities do not produce blood slide results that meet the minimum standard needed to guide clinical decisions due to a lack of refresher training for malaria microscopy as previously reported by Mbakilwa et al. (2012) [23]. A previous study that was carried out in Dar-es-Salaam, revealed a low level of quality in routine malaria microscopy in health facilities in the area, especially at the hospital level [24].

A report from Kenya shows that microscopists who had completed refresher training and worked in a QA-pilot facility proved to perform well with the best competence in general [25]. The QA program and formal microscopy refresher training should be systematically implemented together to improve the parasitological diagnosis of malaria by microscopy. There is also good evidence from Ethiopia that most laboratories lacked refresher training and quality assessment, emphasizing the need for improved logistics, ongoing training, and quality control programs to enhance malaria diagnosis accuracy [26].

Training in malaria microscopy was also reported to be poor in Uganda similar to our findings, suggesting the need for in-service training to enhance accuracy, particularly in the public sector where malaria microscopy quality remains a challenge [27]. Surprisingly, reports on selected primary healthcare facilities in Tanzania showed no substantial improvement in the performance of microscopy despite refresher training for laboratory technicians and supervision [28]. This implies that training needs to be properly planned and regular, considering the high turnover of staff. In addition, other important factors need to be considered too, such as basic health facility infrastructure, levels of laboratory staffing, supervision, and availability of essential laboratory supplies.

Poor malaria microscopy inevitably results in several adverse consequences including inadequate treatment of patients who have malaria, waste of scarce resources, and loss of confidence among physicians and their patients in the validity of laboratory results.

High-quality malaria microscopy requires regular training and supervision of laboratory practitioners at primary healthcare facilities to confirm screening results by malaria Rapid Diagnostic Tests (mRDTs) that can provide a reliable treatment decision-making, hence improving health outcomes and reinforcing trust in diagnostic processes at the primary health facilities.

5. Limitations of the Study

Responses from the participants especially on factors affecting their competence were self-reported and might be biased.

6. Conclusion

Laboratory practitioners were not competent enough in malaria microscopy for the detection and quantification of malaria parasites. However, participants were more competent in the detection of malaria parasites than quantification of the parasites. The majority of the participants in this study who had training in malaria microscopy performed better than the ones who had no training. Training in malaria microscopy was found to be the main factor that was associated with the competence of laboratory practitioners in the study area. Competence in the diagnosis of malaria by blood slide microscopy for accurate results can be achieved by qualified well-trained laboratory practitioners supported by continuous regular training on malaria microscopy.

Abbreviations

AIDS	Acquired Immunodeficiency Syndrome
AOR	Adjusted Odds Ratio
COR	Crude Odds Ratio
DLT	District Laboratory Technician
EQA	External Quality Assessment
HIV	Human Immunodeficiency Virus
HLPC	Health Laboratory Practitioners Council
IQA	Internal Quality Assessment
KCMUCo	Kilimanjaro Christian Medical University College
mRDT	malaria Rapid Diagnostic Test
NMCP	National Malaria Control Program
QA	Quality Assessment
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization

Acknowledgments

The authors wish to acknowledge cooperation and invaluable assistance provided by the laboratory managers and Medical Officers in-charge of all health facilities where the study was carried out. Their willingness to facilitate access to essential resources, data and expertise greatly enhanced our field work and data collection processes.

Sincere heartfelt and special thanks are extended to Dr. James Ngocho and Dr. Johnstone George of the KCMC University School of Public Health whose expertise and guidance were pivotal in refining our research approach and ensuring rigorous quality control throughout the study.

Author Contributions

Emmanuel Macha: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing – original draft

Doreen Mayemba: Conceptualization, Data curation, Investigation, Methodology

Calvin Ngowi: Data curation, Investigation, Methodology

Happiness Rutunda: Data curation, Investigation, Methodology

Innocent Kamwamwa: Data curation, Investigation, Methodology, Supervision

Balthazar Nyombi: Conceptualization, Methodology, Investigation, Formal analysis, Writing-review and editing

Johnson Matowo: Conceptualization, Formal Analysis, Investigation, Methodology, Supervision, Writing – review & editing

Ethical Approval and Consent to Participate

Ethical approval was obtained from the KCMC University Research Ethics Review Committee after submitting a proposal. A permission letter for data collection was obtained from the College with reference number UG 117 /2024.

Confidentiality was maintained where participants were assigned unique identification numbers instead of their names. Written informed consent was sought from participants prior to study initiation. The authors declare that they have no competing interests.

Consent for Publication

The consent to publish is not applicable in this submission.

Funding

We did not receive any funding for this study.

Conflicts of Interest

The authors declare no conflicts of interest.

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