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MORALITY BEFORE KNOWLEDGE

The relationship between internal quality assurance of malaria parasite testing and the quality of malaria slides at regional general hospital

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ABSTRACT
Background: Malaria Internal Quality Control (IQC) is a mandatory activity done by the malaria examining laboratory. It includes the entire steps of malaria examination from pre-analytical, analytic, and post-analytic in order to obtain good results of malaria microscopic examination in the form of qualified preparation. The study aimed to find out the correlation between internal quality control and malaria preparation quality at regional general hospital laboratory. **Methods:** This type of research is analytic observational with a cross-sectional study design. The samples in this research were selected using total sampling, with 7 laboratory officers interviewed and observed about pre-analytical to post-analytical processes. 23 positive preparations in 2021 were then subjected to macroscopic and microscopic observations and assessment of malaria preparation quality. Statistical analysis used the Pearson test processed using SPSS 25. **Findings:** The results showed that the percentage for the implementation of Internal Quality Assurance (IQA) was 86%, while the percentage of preparation quality was 82%. Based on the Pearson correlation test between IQA and the quality of malaria preparations, a p-value of 0.010 was obtained ($p < 0.05$), which means that there is a relationship between IQA and the quality of malaria preparations. **Conclusion:** The percentage of IQA implementation by laboratory staff at regional general hospital covering the pre-analytical, analytical, and post-analytical stages was 86%. Meanwhile, the quality percentage of laboratory preparations based on components such as thick blood smears, thin blood smears, staining, and species accuracy was 82% out of the 23 slides present in the laboratory in 2021. **Novelty/Originality of this article:** This study presents new evidence regarding IQA for malaria parasite testing, specifically concerning the quality of malaria slide preparations at the hospital laboratory, to support disease control efforts and the malaria program.

KEYWORDS: internal quality control; malaria microscopic examination; malaria preparation.

1. Introduction

Malaria is an infectious disease that remains a public health issue, affecting various aspects of life in Indonesia. Commitment to controlling this disease should be a priority for us all not only at the national level but also regionally and globally in line with the outcomes of the 60th World Health Assembly (WHA) meeting held in Geneva in 2007 regarding malaria elimination (Ministry of Health, 2017).

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The malaria control program in Indonesia is outlined in the Decree of the Minister of Health of the Republic of Indonesia Number 293/MENKES/SK/IV/2009 regarding Malaria Elimination in Indonesia. Its objective is to achieve a healthy society free from malaria transmission through a phased approach leading up to 2030. The implementation of malaria elimination targets proceeds in stages spanning regencies/cities, provinces, and individual or multiple islands until the entire territory of Indonesia is covered. Assessments are based on the malaria situation and available resources, with the following phased schedule: the Thousand Islands (Special Capital Region of Jakarta), Bali, and Batam in 2010; Java, Nanggroe Aceh Darussalam Province, and Riau Islands Province in 2015; Sumatra (excluding Nanggroe Aceh Darussalam and Riau Islands Provinces), West Nusa Tenggara Province, Kalimantan, and Sulawesi in 2020; and the provinces of Papua, West Papua, Maluku, East Nusa Tenggara, and North Maluku in 2030.

East Nusa Tenggara Province has achieved success as the first region in Eastern Indonesia to see its regencies and cities reach malaria elimination; specifically, Manggarai Regency, East Manggarai Regency, and Kupang City have successfully eliminated the disease. Manggarai Regency achieved elimination in 2019, while East Manggarai Regency and Kupang City did so in 2020. Additionally, there are 14 regencies/cities in the province classified as low-endemic, two as medium-endemic, and three as high-endemic. High-endemic areas remain concentrated on Sumba Island, specifically in East Sumba, Central Sumba, and West Sumba Regencies.

The principle behind reducing case numbers involves screening as many residents as possible for malaria to detect all parasites in the human body and ensuring they receive complete, standardized treatment (Alfaiza & Wuryaningsih, 2022). In 2020, the endemicity map showed 15,341 cases distributed across the island of Sumba. By 2021, the number of cases had dropped to 9,396. The Annual Parasite Incidence (API) across the three endemic regencies of Sumba remained above 1. East Sumba recorded an API of 6.57 and an Annual Blood Examination Rate (ABER) of 15%; the number of examinations rose from 35,890 in 2020 to 40,522 in 2021, while the number of positive malaria cases increased from 1,639 in 2020 to 1,718 in 2022.

To improve the quality of malaria testing, it is necessary to map the malaria laboratory network. This network comprises laboratories providing services to patients with suspected malaria across various tiers ranging from primary healthcare facilities to central-level institutions thereby supporting control programs aimed at malaria elimination (Fitriany & Ahmad, 2018). High-quality laboratory services are essential for malaria case detection, a factor heavily dependent on the competence and performance of laboratory personnel at every level of the healthcare system. Strengthening quality malaria testing laboratories involves network development and quality assurance across the spectrum of testing facilities including Community Health Centers/*Pusat Kesehatan Masyarakat* (Puskesmas), hospitals, and private laboratories extending to cross-check reference laboratories at the district/city, provincial, and central levels (Ministry of Health, 2020).

Internal Quality Control (IQC) is a crucial factor in ensuring the accuracy of laboratory test results. For malaria diagnostic laboratories, IQC comprises a series of continuous management efforts including detection, prevention, and monitoring aimed at achieving precise and accurate malaria test results (Directorate General of Disease Control and Environmental Health, 2008; Prabowo, 2014). The laboratory microscopic examination process involves three stages: pre-analytical, analytical, and post-analytical. Errors whether unavoidable or difficult to avoid can occur at any of these stages. Pre-analytical errors account for the largest share at 68%, while analytical errors constitute 13% and post-analytical errors around 19%. Consequently, every laboratory is required to enhance and maintain performance quality by implementing continuous IQC (Usman et al., 2015). Based on the description above, the author conducted research on the relationship between internal quality assurance for malaria parasite testing and the quality of malaria smears at the laboratory of Umbu Rara Meha Regional General Hospital, Waingapu.

2. Methods

The aim of this study was to determine the relationship between internal quality control of malaria parasite testing and the quality of malaria smears at the Laboratory of Umbu Rara Meha Regional General Hospital, Waingapu with the specific objective of determining the implementation of internal quality assurance for malaria testing (pre-analytical, analytical, and post-analytical phases) and assessing the quality of malaria smears based on criteria such as smear morphology, staining, and reading results and to determine the relationship between internal quality assurance for malaria microscopy and the quality of malaria smears. This study employs a correlational analysis method to measure the relationship between Internal Quality Assurance for malaria parasite testing and the quality of malaria smears at the Laboratory of Umbu Rara Meha Regional General Hospital, Waingapu.

2.1 Data study

The study population consisted of all laboratory personnel and all malaria specimens from 2021 at the laboratory of Umbu Rara Meha Waingapu Regional General Hospital The sample in this study consisted of 7 laboratory personnel performing malaria examinations and 23 malaria slides and the sample size in this study was determined using the total sample. This study was conducted at the laboratory of Umbu Rara Meha Regional General Hospital in Waingapu and was scheduled to take place from February to August 2022.

2.2 Data sample, collection, material

Laboratory personnel at Umbu Rara Meha Regional General Hospital, Waingapu specifically those with a background as health analysts directly involved in microscopic malaria testing (covering the pre-analytical to post-analytical stages) were studied to assess the implementation of Internal Quality Assurance for malaria laboratory testing and Positive malaria specimens at the Umbu Rara Meha Regional General Hospital Laboratory in Waingapu. The materials used in this study were microscope slides and immersion oil, while the equipment used included a microscope, tissues, and lens paper. The data used in this study are primary data. Primary data were obtained through direct observation to examine the implementation of internal quality assurance using a prepared questionnaire, as well as to directly assess the quality of malaria slides.

2.3 Research procedure

Requesting a research permit recommendation letter from Universitas Perintis Indonesia Padang, arranging research authorization and submitting the permit letter to the Director of Umbu Rara Meha Regional General Hospital in Waingapu, Providing the consent form or questionnaire to the research respondents, Explaining to the respondents how to complete the questionnaire, Next, the respondents were given a questionnaire to answer all the questions provided, Reviewing the answers provided by the respondents and Saving the questionnaire sheet.

Quality assessment of malaria slides, microscope slide (object glass), do not use scratched microscope slides; it is best to use new ones, to clean a slide, wipe it with a tissue or a clean cloth, ensuring you do not touch the glass surface itself and Once the slide is confirmed to be free of grease, it is ready for use and slides should be stored in a slide box made of shatter-resistant plastic or fiber material. Quality assessment of malaria slides is performed by removing a slide from the slide box, placing it on the microscope stage, applying a drop of immersion oil, and examining the slide at 100x magnification. The staining quality results for the preparations are as follows: normal, leukocyte nuclei appear purple, parasite nuclei red, and cytoplasm blue; acidic, leukocyte nuclei appear red, parasite

nuclei red, and cytoplasm red; Basic: leukocyte nuclei appear blue, parasite nuclei blue, and cytoplasm blue; dirty, significant residue such as precipitate, dye particles, or dust is present in the field of view.

Requirements for using a microscope in the examination for malaria parasites: light source, a good light source is essential for obtaining optimal examination results. The light source may be natural sunlight or electric light, powered by batteries or a generator. The lighting must be neither too bright nor too dim, as this can affect the examination of the specimen. Lighting settings, place the specimen on the microscope stage; adjust the lighting by raising the condenser and opening the diaphragm; observe the specimen through the eyepiece using the 10x objective lens. Turn the coarse adjustment knob to focus the field of view (it is not recommended to locate the field of view directly using the 100x lens.); once the field of view has been located and focused, apply a drop of immersion oil to the specimen; then, the objective lens can be rotated to the 100x magnification lens; Observe the field of view; if it is not yet in focus, turn the fine adjustment knob until a clear, focused view is obtained (using the coarse adjustment knob directly is not recommended).

Microscopic storage, microscope protection against dust and dirt: it must be covered with a clean cloth or a microscope cover; if the microscope is not to be used for an extended period, it should be stored in its case or cabinet with the lenses in the "rest" position specifically, with the objective lens set to 10x magnification; after use, the objective and ocular lenses should be cleaned with microscope tissue; a 7:3 mixture of ether and alcohol may be used to remove immersion oil. Protection against fungi: store the microscope in a dry place. It can be stored in an air-conditioned room where the AC runs 24 hours a day (without being turned off); if 24-hour air conditioning is not available, the microscope may be stored in a microscope cabinet or case; microscopes are stored in cabinets equipped with a light bulb rated between 25 and 50 watts, depending on the cabinet's size that must remain switched on continuously. If stored in a microscope case, a 5-watt bulb may be used instead; If adequate electrical facilities are unavailable, the microscope can be stored in its case, with 400g of silica gel placed inside; if the microscope is not to be used for an extended period, all objective and ocular lenses must be stored separately in a desiccator or a glass jar containing silica gel. If the silica gel changes color from blue to pink, it can be regenerated by heating; If the microscope lens develops mold, it must be serviced directly by a microscope technician (Ministry of Health, 2017). This case report was prepared in accordance with ethical principles. Confidentiality has been maintained, and all information that could reveal the patient's identity has been anonymized.

3. Results and Discussion

3.1 Research Results

This study was conducted from April to June 2022, utilizing a sample of seven laboratory personnel and 23 positive malaria slides from 2021, selected based on inclusion criteria. The research took place at the Clinical Pathology Laboratory Unit of Umbu Rara Meha Regional General Hospital in Waingapu, involving the observation of internal quality assurance practices and the assessment of malaria slide quality.

3.1.1 General characteristics of research

The results obtained from the research questionnaire are as follows on Table 1. An observational study with a cross-sectional design was conducted involving seven laboratory staff members at Umbu Rara Meha Waingapu Regional General Hospital between June 14 and 17, 2022, at the hospital's laboratory. One of the seven respondents was male. The questionnaire consisted of 26 questions categorized as follows: 8 pre-analytical, 9 analytical, and 9 post-analytical questions. A "yes" answer was assigned a value of 1, while a "no" answer was assigned a value of 0; the correct responses were subsequently presented as percentages and categorized.

Table 1. Research questionnaire results

Questionnaire Assessment (People)	Pre-Analytical	Analytical	Post-Analytical	Mean	Percentage (%)
Good	7	4	7	6	86
Enough	0	2	0	1	10
Insufficient	0	1	0	0	4
Quantity	7	7	7	7	100

Research questionnaire results constitute a crucial component of a scholarly work, serving to present, analyze, and interpret the data collected from respondents. This stage transforms raw data such as numerical figures or selected responses into valid scientific information capable of addressing the research hypotheses. First is quality assessment of malaria slides. The results of the slide quality assessment are as follows on Table 2.

Table 2. Quality assessment of malaria slides

Evaluation of Preparations	Thin Smear	Thick Smear	Staining	Accuracy	Mean	Percentage (%)
Good	14	18	20	23	19	82
Enough	9	5	3	0	5	18
Insufficient	0	0	0	0	0	0
Quantity	23	23	23	23	23	100

Throughout 2021, these seven laboratory staff members identified 23 positive malaria cases at the Umbu Rara Meha Waingapu Regional General Hospital laboratory, with each staff member responsible for one of the positive cases detected. The assessment of malaria slide quality was based on criteria covering thin blood smears, thick blood smears, staining quality, and the accuracy of reading results. The assessment comprised four components, each weighted at 25%, resulting in a total score of 100%.

Table 3. SPSS analysis

	Mean	Std. Deviation	N
Internal Quality Assurance	87.04	6.14	23
Quality of Preparations	84.09	4.08	23

Quality assessment of malaria blood smears is the process of verifying the quality of the preparation and staining of microscopic slides to ensure diagnostic accuracy. Microscopic examination remains the gold standard for diagnosing malaria. To ensure diagnostic accuracy, the prepared blood smears must meet specific quality parameters so that Plasmodium parasites can be precisely identified. Furthermore there are the statistical analysis using SPSS yielded the following mean values for the questionnaire assessments and specimen quality ratings on Table 3. The analysis results indicate that, on average, the questionnaire items are suitable for conducting research on the variables under study.

3.1.2 The relationship between internal quality assurance and the quality of malaria slides

Before examining the relationship between Internal Quality Assurance and the quality of malaria smears, the data distribution was assessed using the Shapiro-Wilk normality test. Statistically, the data were found to be normally distributed ($p > 0.05$), with p-values of 0.092 for Internal Quality Assurance and 0.224 for malaria smear quality. Next, to examine the relationship between the two variables given that the data are normally distributed a Pearson correlation test was conducted. The results of the Pearson correlation test yielded the following two categories Table 4.

Table 4. Normality data

	Shapiro – Wilk		
	Statistic	Df	Sig.
Internal Quality Assurance	0.926	23	0.092
Quality of Preparations	0.944	23	0.224

Based on the Pearson correlation test results in the table above, a relationship is evident from the p-value (< 0.05); furthermore, the correlation value indicates a moderate relationship between Internal Quality Assurance and the quality of malaria slide preparations. Statistically, this is demonstrated by a correlation coefficient of 0.523. There is a highly significant, direct relationship between the implementation of Internal Quality Assurance (IQA) and the quality of malaria slide preparations in the laboratory; this demonstrates that when IQA protocols are rigorously applied at every stage of the examination, error rates can be minimized, resulting in malaria blood smears that meet the gold standard for accurate diagnosis.

Table 5. The relationship between internal quality assurance and the quality of malaria slides

	Mean + SD	Correlation	p-value
Internal Quality Assurance	87.04 + 6.138	0.523	0.010
Quality of Malaria Slides	84.09 + 4.078		

3.2 General characteristics of research

This study found that the performance of Internal Quality Assurance at the Umbu Rara Meha Waingapu Regional General Hospital laboratory covering stages from pre-analytical to post-analytical achieved a score of 86%, while the quality of malaria slide preparations scored 82%. The percentage scores are classified into three categories: "Good" (above 80%), "Fair" (60–79%), and "Poor" (below 60%). Consequently, both variables in this study Internal Quality Assurance implementation and malaria slide preparation quality fell into the "Good" category.

Based on the average responses to the questionnaire administered to laboratory staff at Umbu Rara Meha Waingapu Regional General Hospital, no pre-analytical steps were overlooked during the implementation of Internal Quality Control for malaria microscopy examinations. As the initial phase of the malaria testing process, the pre-analytical stage is a crucial component that influences subsequent stages (World Health Organization (WHO), 2010). Pre-analytical factors can account for up to 68% of errors in test results; however, if this stage is executed correctly in accordance with established work instructions, the resulting test outcomes can be assured to be accurate (Usman et al., 2015).

In assessing the quality of malaria slides, the researcher relied on direct observation supplemented by evaluations from malaria cross-checkers using the *e-sismal* application a tool employed by district-level cross-checkers to review slides from health facilities. The assessment criteria covered the preparation of thin and thick blood smears, the staining process, and the accuracy of species identification. Based on these aspects, the overall slide quality was determined to be 82%.

Poor specimen preparation leads to errors in reporting laboratory results, which in turn can result in misdiagnosis and incorrect patient treatment. Substandard preparations are typically characterized by excessive thickness, unevenness, contamination, over-staining, or errors in result interpretation. These findings align with previous research by Jaya (2016), which indicated that the accuracy of malaria diagnosis depends on the availability of necessary testing equipment and materials, as well as the presence of competent personnel capable of producing high-quality specimens.

Internal Quality Control conducted in the laboratory is crucial and must be carried out by laboratory personnel to ensure their performance, as well as to verify testing capabilities and the sensitivity and specificity of laboratory diagnoses (Ministry of Health, 2020).

3.3 The relationship between internal quality assurance and the quality of malaria slides

Malaria remains a significant health issue in East Nusa Tenggara. It is also an infectious disease for which control efforts constitute a global commitment under the Millennium Development Goals (MDGs). There are five Plasmodium species that cause malaria in humans (Nugroho & Wagey, 2015): *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium knowlesi*. *Plasmodium falciparum* malaria also known as tropical malaria is a severe form of the disease that can be fatal; symptoms include fever that may be intermittent or continuous. *Plasmodium vivax* malaria also known as tertian malaria presents with fever that recurs every two days. *Plasmodium malariae* malaria also known as quartan malaria presents with fever that recurs every three days. *Plasmodium ovale* malaria presents with fever patterns similar to those of *Plasmodium vivax* malaria, though clinical manifestations are typically mild. *Plasmodium knowlesi* malaria presents with fever patterns similar to those of *Plasmodium falciparum* malaria (Ministry of Health, 2019).

Malaria conditions vary across endemic areas. Measuring the spleen rate, parasite rate, and sporozoite rate collectively known as malariometric indices serves as a method to assess the degree of endemicity. *Plasmodium vivax* has the widest geographical distribution, ranging from cold and subtropical climates to tropical regions. *Plasmodium* falciparum is rarely found in cold climates but is most frequently encountered in tropical regions. The distribution of *Plasmodium malariae* is similar to that of *Plasmodium falciparum*, *Plasmodium malariae* is far less common and exhibits a sporadic distribution. Among all human Plasmodium species, *Plasmodium ovale* is the least common; it is found primarily in tropical Africa and occasionally in the Western Pacific region. In Indonesia, *Plasmodium falciparum* and *Plasmodium vivax* are generally the most frequently encountered species; *Plasmodium malariae* is rarely found mostly in eastern Indonesia while *Plasmodium ovale* is even rarer (Arsin et al., 2012).

A diagnosis of malaria is established based on clinical symptoms, laboratory tests, and ancillary examinations. A definitive diagnosis is confirmed by the detection of malaria parasites via microscopic examination (Harijanto, 2014). Common symptoms of malaria include fever lasting more than two days, chills, and sweating. However, fever patterns differ depending on the Plasmodium species: *Plasmodium falciparum* causes daily fever; *Plasmodium vivax* and *Plasmodium ovale* cause fever every other day; and *Plasmodium malariae* causes fever with a two-day interval between episodes (Widoyono, 2011). Patients typically present with body temperatures ranging from 37.5°C to 40°C and exhibit anemia, evidenced by pale palpebral conjunctivae. Splenomegaly (enlarged spleen) and hepatomegaly (enlarged liver) may also be observed. Severe malaria is frequently associated with altered consciousness, dehydration, and neurological symptoms (Widoyono, 2011).

Microscopic examination is a blood test utilizing thick and thin blood smears to diagnose the presence of malaria parasites. Thick and thin smears constitute the gold standard for establishing a malaria diagnosis (Mau & Murhandarwati, 2015). Giemsa staining allows for the determination of parasite density and the differentiation of malaria species and their developmental stages, even at low densities. Quantitative parasite density is calculated by counting the number of parasites per 200 leukocytes in thick smears, whereas in thin smears, the count is based on the number of parasites per 1,000 erythrocytes. Additionally, supportive tests may be performed, including measurements of hemoglobin (Hb) levels, hematocrit, and erythrocyte, leukocyte, and platelet counts, as well as blood chemistry analysis, chest X-rays, ECGs, and other examinations based on clinical indications. These tests aim to assess the patient's general condition (Widoyono, 2011).

In malaria control efforts, laboratory testing whether via microscopy or Rapid Diagnostic Tests (RDTs) is a crucial component; consequently, ensuring high quality microscopic examination is a primary concern (Ritung et al., 2018). Delivering quality microscopic malaria testing relies heavily on staff competence and performance,

infrastructure, the availability of consumables and equipment, and the production of slides that meet established standards. Achieving high-quality microscopic testing requires a shared commitment to quality assurance, supported by effective training, cross-checking, and technical guidance, alongside a logistics system that ensures the adequate and continuous supply of equipment and materials (Ministry of Health, 2020).

Internal Quality Control (IQC) consists of preventive and monitoring activities continuously carried out by individual laboratories to prevent or minimize errors and deviations, thereby ensuring accurate laboratory test results. Internal quality assurance is crucial and must be carried out by laboratory personnel to monitor performance and ensure testing proficiency, as well as the sensitivity and specificity of laboratory diagnoses. This activity is integral to the quality of laboratory testing; therefore, every clinical laboratory is required to enhance and maintain testing quality through the continuous implementation of internal quality assurance (Ministry of Health, 2017).

The analysis of the relationship between internal quality assurance for malaria testing and the quality of malaria smears indicates a significant association between the internal quality assurance measures and the quality of smears produced in the laboratory. These results confirm that the research hypothesis (Ha) is accepted. Microscopic examination remains the gold standard for the definitive diagnosis of malaria. Malaria testing involves the preparation of thick and thin blood smears to determine three key factors: the presence or absence of malaria parasites (positive/negative), the parasite species and developmental stage, and the parasite density (Ministry of Health, 2013).

One factor contributing to the failure of malaria control efforts is misdiagnosis during microscopic examination, a known limitation of this diagnostic method. Such errors can originate at the Community Health Center/*Pusat Kesehatan Masyarakat* (Puskesmas) level during the microscopic identification of malaria parasites in blood smears performed by center staff (Directorate General of Disease Control and Environmental Health, 2012; 2016). The proficiency of laboratory personnel specifically in preparing, staining, and interpreting blood smears is crucial for the successful detection of malaria parasites. Consequently, the accuracy and validity of blood smear examinations performed by laboratory staff require continuous monitoring and oversight (Everald et al., 2015). Poor quality microscopes and reagents, combined with a lack of adequate training among examiners, create obstacles for microscopic malaria parasite detection a method that has long served as the gold standard for laboratory diagnosis of malaria (L et al., 2006).

The assessment parameters for internal quality assurance are divided into three stages: pre-analytical, analytical, and post-analytical. Each stage comprises several activities; the pre-analytical stage includes reagent quality testing, while the analytical stage involves preparing thick and thin malaria blood smears, staining the smears, reading samples, and reporting test results. The post-analytical stage encompasses recording test results, tiered supervision, and documenting all testing activities to ensure traceability.

Quality assurance implementation serves as a means of maintaining and monitoring the quality of laboratory examinations. This includes internal quality assurance for malaria microscopy, which must be consistently carried out within the health facility or Community Health Center/*Pusat Kesehatan Masyarakat* (Puskesmas) itself to uphold laboratory quality standards and support patient diagnosis specifically for malaria patients (Gunasari, 2018). The implementation of internal quality assurance for malaria microscopy comprises three stages: pre-analytical, analytical, and post-analytical. Each stage consists of several mandatory activities that must be fully executed to optimize the overall internal quality assurance process for malaria microscopy. As previously outlined, effective internal quality assurance is achieved when all activities across the pre-analytical, analytical, and post-analytical stages are completed resulting in a 100% completion rate where no single activity is overlooked.

The significant relationship observed between the implementation of effective Internal Quality Assurance (IQA) and the quality of the resulting malaria slides leads to the conclusion that personnel adherence to standard operating procedures and applicable

regulations specifically regarding the execution of IQA protocols yields high-quality malaria slides. This, in turn, facilitates accurate patient diagnosis, ensuring that the treatment prescribed by the clinician is effective. Furthermore, the laboratory avoids operational obstacles and issues because all workflows comply with established Standard Operating Procedures (Ministry of Health, 2013).

Based on the research conducted, data regarding the demographic characteristics of laboratory staff categorized by gender, education, employment status, and length of service revealed that at Regional Public Hospital Umbu Rara Meha in East Sumba Regency, out of a total of seven laboratory staff members, six were female (85.71%) and one was male (14.28%). This aligns with data from the East Sumba Central Branch Executive Board of the Indonesian Association of Medical Laboratory Technologists/*Dewan Pimpinan Cabang Persatuan Ahli Teknologi Laboratorium Medik Indonesia* (DPC PATELKI) regarding laboratory personnel at Umbu Rara Meha Regional General Hospital; in terms of educational background, the workforce is dominated by those holding a Diploma III in Medical Laboratory Technology. This is consistent with the East Sumba Patelki DPC SIMK data regarding the total number of medical laboratory technology personnel with D III qualifications. The most common employment status among these personnel is State Civil Apparatus/*Aparatur Sipil Negara* (ASN), and the majority have a tenure of more than 10 years. According to the Ministry of Health (2020), the minimum educational requirement for performing malaria examinations is a Diploma III in Medical Laboratory Technology; this aligns with research conducted by Jebanur (2020) an analysis of the performance of malaria microscopists at Community Health Centers/*Pusat Kesehatan Masyarakat* (Puskesmas) in East Manggarai Regency, East Nusa Tenggara Province and research by Siahaan & Restuty (2021), which found no significant influence of education level, length of service, or employment status on the performance of laboratory personnel.

Meanwhile, microscopy training activities were conducted with the aim of enhancing the skills and accuracy of malaria examinations performed by hospital laboratory personnel. Laboratory staff are required to undergo microscopy training that meets at least the Level III standard. Research findings revealed that, among the hospital's laboratory staff, five individuals had completed Level III (or higher) microscopy training within the last five years (Permadi, 2012). Reports from the 2021 malaria information and surveillance system indicate that, across 4,426 health facilities, a total of 5,628 Medical Laboratory Technology personnel participated in malaria microscopy training. Of these 5,628 personnel, 4,122 (approximately 73%) including those at Umbu Rara Meha Hospital in East Sumba Regency had never undergone malaria microscopy training.

These data indicate a need for regular training for laboratory personnel to enhance their expertise, skills, and the accuracy of malaria testing data. It was found that 100% of the Standard Operating Procedures (SOPs) for malaria testing in East Sumba Regency, East Nusa Tenggara Province, were incomplete according to established malaria testing guidelines. Having complete SOP documentation for malaria testing is crucial for every community health center/*pusat kesehatan masyarakat* (Puskesmas) laboratory. Complete SOP documentation reflects a laboratory management system that operates effectively, safely, and in compliance with established standards whether in the context of research, testing, or education (Irma & Sabilu, 2021). Standard Operating Procedure (SOP) documents for malaria testing play a pivotal role in ensuring the consistency and quality of laboratory services, particularly at community health centers serving as the frontline of healthcare. In the context of Medical Laboratory Technology, an SOP serves as a written guide that systematically outlines the technical steps for malaria testing ranging from capillary blood sampling and slide preparation and staining to microscopic interpretation and result reporting. Without clear and up to date SOP guidelines, there is a high risk of procedural variation among analysts, which can compromise the validity of test results and undermine Internal Quality Control (IQC) processes. Adherence to SOP documents is a key indicator in the evaluation of laboratory quality. Well documented SOP enable laboratory personnel to work according to standardized principles, reduce the risk of technical errors,

and facilitate the training of new staff or personnel rotations. In the context of Internal Quality Control (IQC) evaluation, SOPs serve as a metric for procedural performance and as a basis for quality audits to assess whether testing procedures align with diagnostic standards. Therefore, every community health center must ensure that malaria testing SOPs are available, easily accessible, periodically updated, and consistently implemented by all laboratory personnel.

Based on data regarding the completeness of Standard Operating Procedure (SOP) documentation, malaria testing at Umbu Rara Meha General Hospital in East Sumba Regency falls into the "insufficient" category; the facility lacks the full set of SOP documents required for laboratory management protocols and has not fully detailed the supporting documentation for malaria testing procedures. This situation warrants special attention from hospital management to address recommendations regarding the procurement of complete SOP documentation that meets required laboratory standards. By carefully attending to these stages, the laboratory can ensure that the tests performed are of optimal quality and reliable (Ministry of Health, 2020).

Field observations by the researchers revealed that, regarding laboratory equipment, the facilities possessed adequate gear to support various laboratory tests. As for laboratory materials, the supplies at all community health centers were generally sufficient; however, quality control for the reagents to be used was necessary. The study results indicated that quality control for reagents used in microscopic malaria testing fell into the "poor" category a factor that inevitably impacts the quality of the malaria specimens being examined. Poor preparation and staining of blood smears contribute to high rates of false-positive and false-negative results (Ariyanti et al., 2012).

The availability of high quality laboratory equipment and materials is a crucial component in ensuring the quality of diagnostic testing, including malaria detection at both primary and advanced care levels. Malaria testing particularly via microscopy requires precise equipment, such as high resolution binocular microscopes, as well as quality consumables like microscope slides, Giemsa stain, buffer solutions, and other supporting reagents. Shortages in these essential tools and materials can lead to the misinterpretation of results and reduced diagnostic accuracy, ultimately resulting in delayed patient treatment (Siahaan, 2019).

Within the framework of internal quality assurance, the adequacy of laboratory equipment and materials not only impacts technical testing processes but also serves as an indicator of the laboratory's overall quality system readiness. Internal quality assurance requires processes such as repeat testing, quality control of specimens, and reliable documentation of results. Without adequate equipment and materials in good condition, the internal quality assurance evaluation process is compromised, as it fails to accurately reflect the laboratory personnel's actual capability to consistently detect malaria parasites.

Modern medical laboratory technology prioritizes efficiency, accuracy, and integrated quality standards. However, even the most sophisticated technology cannot be fully utilized without the support of a comprehensive range of equipment and materials that are ready for immediate use (Rinawati & Fify, 2019). Therefore, meeting laboratory logistics needs ranging from the procurement of laboratory grade microscopes, fixation tools, and timers to temperature stable specimen storage must be a key focus when evaluating and strengthening the PMI system, particularly in areas with high malaria endemicity, such as East Sumba Regency.

The adequacy of equipment and materials is closely linked to the competence of laboratory personnel in implementing standard operating procedures. Equipment that meets specifications enables personnel to work efficiently and accurately, minimizes technical errors, and supports continuous learning through regular training and evaluation. This aligns with the principles of developing technology-driven laboratories focused on service quality, where the quality of malaria test results reflects the synergy between human resource readiness and the adequacy of facilities.

Record keeping and reporting are integral components of effective laboratory management. Every laboratory test must be entered into the malaria register, serving as a reference for laboratory personnel during follow-up monitoring. Proper record keeping and reporting help prevent data errors and ensure the accuracy of medical diagnoses based on laboratory results. Observations from the study revealed that, while overall record-keeping and reporting at the community health center laboratory were generally adequate, the specific component regarding slide cross-checking remained very low. Documenting and reporting malaria test results are crucial for malaria control and elimination efforts. Accurate and timely data facilitate effective decision making, efficient resource allocation, and the monitoring of malaria control program progress (Siregar et al., 2018).In the practice of medical laboratory technology, record keeping is not merely a passive administrative task; rather, it serves as a tool for tracking non conformities, auditing processes, and measuring testing performance. This is particularly crucial for health facilities serving communities in endemic areas such as East Sumba Regency where well documented laboratory data are essential for mapping cases, assessing disease burden, and making evidence based decisions within malaria control programs.

Based on the Pearson correlation test results, a relationship was identified (p-value < 0.05); specifically, a moderate correlation was found between Internal Quality Assurance and the quality of malaria slide preparations. Statistically, this is demonstrated by a correlation coefficient of 0.523, indicating a significant relationship. A higher correlation value signifies a stronger degree of association between the variables under study.

Conducting internal quality assurance is a mandatory task for laboratory personnel; when this process is carried out correctly, the resulting test outcomes are of high quality. A 2017 study by Kandidus indicated a direct correlation between internal quality assurance and the quality of test results specifically regarding malaria slide preparations. As a referral center within the East Sumba Regency service area, the Umbu Rara Meha Regional General Hospital laboratory is committed to continuously improving its quality standards. In addition to performing continuous internal quality assurance a requirement for laboratory staff the laboratory also participates in external quality assurance programs (Konoralma et al., 2017).

Three methods are employed for the External Quality Assurance of malaria testing laboratories: microscopic cross-checking, panel testing, and technical guidance. According to the laboratory's supervising physician, Dr. Benny Wijaya Tambunan, M.Kes, Sp.PK, the Umbu Rara Meha Regional General Hospital Laboratory participated in microscopic cross-checking; malaria slides from 2021 were sent to the Surabaya Health Laboratory Center/*Balai Besar Laboratorium Kesehatan Masyrakat* (BBLK) in early 2022, and the resulting External Quality Assurance assessment was "Very Good" (Grade A).

These excellent external quality assurance results demonstrate a strong correlation between effective Internal Quality Assurance practices and the quality of the prepared samples, resulting in an outstanding performance by the Umbu Rara Meha Regional General Hospital laboratory in external quality assurance, particularly in the field of malaria parasitology (Soedarto, 2011). Laboratory personnel or Medical Laboratory Technologists/*Ahli Teknologi Laboratorium Medik* (ATLM), are crucial because they ensure the accuracy of sample test results that form the basis for medical decisions and patient safety. The laboratory testing process begins with the collection and receipt of samples, such as blood, urine, or sputum. Each sample must be handled according to proper procedures to ensure its quality is maintained. Even minor errors at this initial stage can affect the overall test results. In the laboratory, medical laboratory personnel perform various types of analyses ranging from hematology, clinical chemistry, and microbiology to increasingly advanced technology based methods as required by the specific tests. This process demands precision, skill, and a solid understanding of working methods. In addition to performing analyses, Medical Laboratory Technologists are responsible for maintaining the quality of testing and ensuring workplace safety. Quality control of equipment and materials is conducted routinely to guarantee consistent and accurate results. Meanwhile, the

implementation of laboratory safety protocols is essential to protect personnel and the surrounding environment. This role demonstrates that the work of Medical Laboratory Technologists is not merely technical in nature but entails a significant responsibility regarding the quality of healthcare services.

Laboratory test figures and data do not stand in isolation. Medical laboratory professionals ensure that these results are valid and ready for use by other healthcare providers as a basis for medical decision making. In other words, diagnostic accuracy and the success of therapy depend heavily on the quality of laboratory testing. To fulfill this role, medical laboratory personnel undergo structured education and training. In the Medical Laboratory Technology study program, students not only study theory but also gain early exposure to laboratory practicums, work standards, and professional ethics. This approach aims to produce graduates who are competent, professional, and prepared to face the challenges of the workforce. As healthcare services and laboratory technologies advance, the demand for competent medical laboratory personnel continues to rise. This profession plays a strategic role in everything from the early detection of diseases and patient condition monitoring to supporting public health programs. Medical laboratory personnel are a vital part of the healthcare system, working with precision, responsibility, and a high level of dedication.

4. Conclusions

The percentage of Internal Quality Assurance implementation by laboratory staff at Umbu Rara Meha Regional General Hospital covering the pre-analytical, analytical, and post-analytical stages was 86%. Meanwhile, the quality percentage of laboratory preparations based on components such as thick blood smears, thin blood smears, staining, and species accuracy was 82% out of the 23 slides present in the laboratory in 2021. Based on the results of the Pearson correlation test between the two variables internal quality assurance and malaria slide quality a p-value of 0.010 was obtained ($p < 0.05$), indicating the existence of a relationship; the correlation coefficient of 0.523 signifies a moderate degree of correlation.

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