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ASSESSING THE ACCURACY OF MALARIA DIAGNOSTIC METHODS ON EFFICIENT COMMUNITY MEDICINE PRACTICE IN PRIMARY HEALTH CARE SETTINGS IN BORNO STATE.

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ABSTRACT

Malaria remains a major public health challenge in sub-Saharan Africa, particularly in Nigeria. The disease is strongly associated with anemia, especially in vulnerable populations such as children and individuals with anemia. Rapid Diagnostic Tests are widely used for malaria diagnosis due to their accessibility, but their accuracy compared to microscopy, the gold standard, may differ. This study aimed to evaluate the comparability of malaria parasitemia diagnosis using Rapid Diagnostic Tests and light microscopy and assess the relationship between Packed Cell Volume and malaria parasitemia in a primary health care setting in Borno State, Nigeria. A hospital based cross-sectional study was conducted among 200 participants, comprising adults and children. Blood samples were tested using Rapid Diagnostic Tests and light microscopy to diagnose malaria parasitemia. Sensitivity and specificity of Rapid Diagnostic Tests were calculated and compared to results from light microscopy as the reference standard. Malaria parasitemia was more prevalent in individuals with anemia, with 27.3% in adults and 44.4 % in children respectively. Sensitivity and specificity of Rapid Diagnostic Tests were 20% and 80%, respectively. While light microscopy had a sensitivity of 75% and specificity of 81.3%. Rapid Diagnostic Tests provide a useful diagnostic tool in resource-limited settings but exhibited lower diagnostic accuracy compared to light microscopy. The higher prevalence of malaria parasitemia among individuals with anemia emphasizes the need for improved diagnostic strategies and includes concurrent management of anemia in malaria-endemic regions.

INTRODUCTION

Malaria remains one of the deadliest parasitic diseases globally, disproportionately affecting low- and middle-income countries, particularly in sub-Saharan Africa. According to the World Health Organization (WHO, 2017,2018), approximately 216 million cases of malaria were reported worldwide in 2016, resulting in 445,000 deaths. Nigeria, being one of the hardest-hit countries, accounts for a large share of the global burden, with malaria contributing significantly to both morbidity and mortality (White et al., 2014; Aju-Ameh,2020). The disease's far-reaching impact extends beyond public health, severely affecting economic development and exacerbating poverty in affected regions (Aregbeshola & Khan, 2018; Uguru et al., 2009).

The primary species responsible for malaria in humans include six *Plasmodium* species, of which *Plasmodium falciparum* is the most prevalent in Nigeria and across sub-Saharan Africa (Kolawole et al.,2023; Yakubu et al.,2019; Olowe et al., 2015). It is associated with severe disease outcomes and high mortality rates, particularly among vulnerable groups such as children and pregnant women (Nicolas & White, 2018). Malaria-related anemia, a common consequence of P. falciparum infection, exacerbates the health burden in endemic regions where the prevalence of parasitemia and anemia is high. Anemia significantly contributes to the overall mortality rate in these settings, further compounding the health challenges faced by impoverished populations. In Nigeria, research has consistently highlighted the relationship between malaria parasitemia and anemia, especially in high-risk populations (Jerimiah et al.,2009). For instance, Ajkeya and Ibukunoluwa, 2019) reported that among children in an Internally Displaced Persons (IDP) camp, malaria and anemia prevalence reached 55.2% and 54.0%, respectively, with a strong correlation between the two conditions. Similarly, studies such as (Oladeinde et al,. 2012; Dawaki et al., 2016) reported high malaria prevalence rates among pregnant women and communities in Northern Nigeria, further emphasizing the risks of anemia and adverse health outcomes.

Effective malaria diagnosis is critical for ensuring timely treatment and reducing complications such as anemia. The Nigerian National Malaria Control Program recommends universal diagnostic testing for all suspected malaria cases using microscopy or rapid diagnostic tests (RDTs) (Federal

Ministry of Health, 2005). However, while microscopy remains the gold standard for diagnosis, it requires trained personnel and functional laboratory infrastructure, which are often unavailable in many primary health care (PHC) settings (Ngasala et al., 2008). In these contexts, RDTs have become the preferred diagnostic tool due to their ability to provide quick, reliable, and early detection of malaria infections (Mbabazi et al., 2015; Mbanefo et al., 2020; McMorrow et al., 2011; Murry& Bennett, 2009). Despite their advantages, RDT kits vary in their sensitivity and specificity, potentially leading to diagnostic inaccuracies. (Abdulkadir et al., 2015; Mbanefo et al., 2020) noted that the inconsistency of RDT performance raises concerns about their reliability, particularly in resource-limited settings where access to confirmatory microscopy is scarce. However, studies such as (Falade et al., 2016) in Southwestern Nigeria demonstrated that prompt and accurate diagnosis using RDTs significantly improved treatment outcomes and reduced the prevalence of severe malaria cases. In the context of Borno State, Nigeria, a region severely affected by conflict and displacement, limited research exists on the relationship between malaria parasitemia, anemia, and the accuracy of diagnostic tools in primary health care settings. Given the region's high malaria burden and the challenges posed by limited healthcare infrastructure, this study aims to assess the diagnostic accuracy of rapid diagnostic test kits in detecting malaria parasitemia and its association with anemia in primary health care settings. This study therefore aims to investigate the diagnostic accuracy of RDTs, and also determine the relationship between malaria parasitemia and anemia

Study Area

Borno State is in the northeastern region of Nigeria and shares international borders with Niger Republic to the northwest, Chad to the northeast, and Cameroon to the east. Its capital, Maiduguri, is a major urban center that serves as the administrative and economic hub of the state. Borno is home to various ethnic groups, with the Kanuri being the predominant ethnic group in the region (Borno, 2021). According to the 2006 census, Borno State had a population of 4,171,104. With an annual population growth rate of 3.2%, the estimated population had risen to 6,306,709 by 2022(NPC, 2006). Maiduguri Metropolitan Council (MMC) is one of the urban local government areas (LGAs) in Borno State and, together with Jere LGA, forms the capital city of Maiduguri. The city is located at a longitude of 11°50' N and a latitude of 13°09' E. Borno State is highly endemic for malaria, with transmission occurring year-round. The

peak malaria transmission season typically spans from July to October, coinciding with the rainy season (Ambe et al.,2020). This makes malaria control and prevention efforts particularly critical in the region, especially given the state's unique challenges, such as limited healthcare infrastructure and ongoing conflict situation.

Sample Size

Sample size was determined using the formula $n = P(1 - P) Z^2/d^2$ (Charan & Biswas, 2013). where n = sample size, P is the estimated prevalence value, d is the error margin at 0.05 (5%), which is the level of significance or precision, and Z is the confidence level of the results (1.96). As described above a total of 200 were examined for fever. meanwhile only 100 consented to have blood samples collected between May to November 2023 for the study among out- patients visiting Primary Health Care Clinic Maiduguri.

Data Analysis

For this study, data was analyzed using the Statistical Package for Social Sciences (SPSS) 25 version. Data was summarized using descriptive statistics; categorical variables were presented using frequencies and percentages. Pearson's Chi- square was used to test associations. Specificity and sensitivity of the diagnostic tests were also calculated. Sensitivity was calculated as True Positive (TP) / True Positive (TP)+False Negative (FN). Specificity was calculated as True Negative (TN) / true negative (TN) +False Positive (FP). Packed cell Volume (PCV) that was below the normal range for the age of the respondent was categorized as abnormal (Anemia present), while within the reference range was categorized as normal (Anemia absent). A $p < 0.05$ was taken as statistically significant.

Ethical Considerations

Ethical Clearance was obtained, and permission was granted by the Local Government Authority and Abbaganaram PHC. Verbal and written permission and consent was obtained from participants, Parents of children were also asked for their assent to samples being taken from children. A child was considered as any individual below the age of 18.

Malaria parasite determination using RDT kits.

Malaria Parasites analysis using Rapid Diagnostic Test (RDT) kit (CareStart ™Malaria HRP2/pLDH(Pf/PvCOMBO Access Bio, Inc., USA). Blood samples collected from individual patients were dropped aseptically onto

the samples well, and two drop of malaria analysis buffer were added based on manufacturer's instruction. The results were read by appearance of double lines viz the control and the test lines on the test kits indicating the presence of plasmodium antigen, likewise negative results were recorded as described by (WHO,2021). Examined by two different microscopists for quality assurance.

Malaria Parasite Determination using Light Microscopy

Blood samples were collected from each participant for malaria parasite detection using light microscopy. Ten percent Giemsa stained thick and thin films were prepared on clean grease-free slides (thin films were fixed with methanol) for malaria microscopy as described by (WHO 2016).

Packed Cell Volume (PCV) Measurement using Microhematocrit Method.

The PCV was determined using microhematocrit technique, the patient blood was collected by pricking the thumb finger of the patients. The blood sample was allowed to flow into a capillary tube which subsequently spun with high-speed centrifuge and the results were recorded for further analysis as described by Monica Chesbrough (Chesbrough, 2005).

Results

Table 1: Sensitivity and specificity of RDT diagnostic Malaria tests

	Malaria fever positive	Malaria fever negative	Total
RDT positive	10 (TP)	10 (FP)	20
RDT negative	40 (FN)	40 (TN)	80
Total	50	50	100

Sensitivity = 10/10+40=10/50=0.20(20%)
Specificity= 40/40+10=40/50=0.80(80%)

Table 1 shows 10 patients who had malaria fever testing positive, while 40 patients who tested negative did not have the disease. RDT test results show a sensitivity of 20% and specificity of 80% respectively.

Table 2: Sensitivity and Specificity of light Microscopy Malaria Tests

	Malaria fever present	Malaria fever absent	Total
Microscopy positive	15 (TP)	15 (FP)	30
Microscopy negative	5 (FN)	65 (TN)	70
Total	20	80	100

Sensitivity=15/15+5=15/25= 0.75 (75%)
Specificity=65/65+15=65/80=0.813 (81.3%)

Table 2 Shows that 15 patients who had malaria fever tested positive by light microscopy, while 65 patients who tested negative did not have the disease. The sensitivity of this test was 75% whereas specificity was 81.3%.

Table 3: Relationship between anemia and malaria parasitemia in adults and children attending PHC clinic in Borno state.

Adults			
PCV	Malaria parasitemia present n(%)	Malaria parasitemia absent n(%)	Total n(%)
Normal	6(10)	54(90)	60(100)
Abnormal	15(27.3)	40(73.7)	55(100)
Total	21(18.3)	94(81.7)	115(100)
	χ^2= 5.7357	p=.016623	Statistically significant
Children			
Normal	4(10)	36(90)	40(100)
Abnormal	20(44.4)	25(55.6)	45(100)
Total	24(28.2)	61(71.8)	85(100)
	χ^2= 12.3991,	p=.00043	Statistically significant

Table 3 shows, A total of 60 adults had normal PCV out of which 6 (10.0%) had malaria parasitemia. Among 55 adults who had abnormal PCV, 15 (27.3%) had positive samples. There was a statistically significant association between the prevalence of malaria parasitemia among adults with abnormal PCV compared to those with normal PCV. While, in the pediatric population, a total of 40 children had normal PCV, out of which 4 (10.0%) had parasitemia. However, among 45 children with abnormal PCV, 20 (44.4%) were found to have positive samples. Children with malaria parasitemia were also more likely to have anaemia. In both adults and children, a higher prevalence of malaria parasitemia was found among those with anemia 27.3% and 44.4% respectively.

DISCUSSION

This study evaluated the diagnostic accuracy of rapid diagnostic tests (RDTs) compared to light microscopy, the gold standard, in detecting malaria parasitemia and explored the relationship between packed cell volume (PCV) and malaria parasitemia. The results revealed variations in diagnostic outcomes between RDTs and microscopy, as well as a higher prevalence of malaria parasitemia among individuals with anemia, especially children. Further emphasizing the need for accurate diagnostic tools in managing malaria and its complications, such as anemia.

The sensitivity (20%) and specificity (80%) of RDTs observed in this study highlight the challenges of relying solely on RDTs for malaria diagnosis, especially in resource-limited settings, where healthcare infrastructure and human resource for health (HRH) is inadequate. Light microscopy, which had a sensitivity of 75% and specificity of 81.3%, remains the gold standard for malaria diagnosis due to its ability to detect low parasitemia levels (White et al., 2014). However, its reliance on skilled personnel, laboratory infrastructure, and time-consuming processes limits its accessibility in many regions (Abdulkadir et al., 2015; Mbanefo et al., 2020; WHO, 1999; WHO,2009) .The lower sensitivity of RDTs compared to microscopy in this study is consistent with previous research, where variability in RDT performance has been attributed to operator proficiency, environmental factors, and parasite density (Ogunfowokan et al., 2020;Oyeyemi et al., 2015;Garba et al.,2016;McMorrow et al., 2011).

A critical limitation of RDTs, particularly in arid regions like Borno State, is the impact of high temperatures on their performance. The WHO has recommended that RDTs be stored and transported at temperatures between 2°C and 30°C to preserve their integrity (WHO, 2009). However, the average temperatures in Borno often exceed 37°C, particularly during April and May when temperatures can reach as high as 42°C (Borno NG Climate Zone, 2024). In such conditions, RDTs may be damaged, and their diagnostic accuracy compromised. Given the reality that many of these tests are transported in unsuitable vehicles and stored in hot environments for extended periods especially in peripheral facilities like PHCs, the discrepancy in RDT sensitivity observed in this study may be partially explained by suboptimal storage conditions. Addressing this issue would require improvements in storage and transport practices, such as using temperature-controlled environments or alternative diagnostic tools better suited to these conditions.

The study's findings on the relationship between malaria parasitemia and anemia, particularly in children, align with earlier research in sub-Saharan Africa (Stark et al., 2022; Jerimiah et al.,2009 Nicolas & White, 2018; White et al., 2014; Ajkeya and Ibukunoluwa, 2019). Anemia is a well-documented consequence of Plasmodium falciparum infection and is particularly prevalent among children and pregnant women (Dondorp et al., 2000). However, it is important to acknowledge that childhood anemia is multifactorial in origin, often influenced by genetic factors (e.g., sickle cell disease), nutritional deficiencies (e.g., iron deficiency anaemia), and other infectious diseases (Stark et al., 2022). This study did not control for these confounding factors, which could affect the interpretation of the relationship between malaria parasitemia and anemia.

The relationship observed between malaria parasitemia, and anemia underscores the need for timely and accurate diagnosis to effectively manage both malaria and its complications, such as anemia. Anemia, particularly in children with malaria, is often the result of multiple mechanisms, including hemolysis of infected red blood cells, bone marrow suppression, and the immune response to infection (Nicolas & White, 2018). Understanding these mechanisms is essential for developing comprehensive treatment strategies that address both malaria and anemia. The need for diagnostic tools that are both sensitive and specific is critical, as missing cases of malaria in patients with anemia could lead to poor clinical outcomes.

The global burden of malaria, particularly in sub-Saharan Africa, underscores the need for improved diagnostic tools. According to the WHO (2020), the region accounts for over 90% of malaria cases and deaths worldwide, making accurate and timely diagnosis essential for effective malaria control. This study reinforces the importance of continued investment in diagnostic research to enhance the sensitivity and specificity of RDTs. Additionally, building capacity in light microscopy use, ensuring access to quality diagnostic tools in hard-to-reach areas and supporting logistic systems must be a priority for healthcare systems in endemic regions. While RDTs provide a practical and accessible diagnostic tool in resource-limited settings, their limitations necessitate the use of confirmatory testing with microscopy, especially in populations at higher risk of anemia. Efforts to improve the storage and transport conditions of RDTs, along with expanded access to microscopy and capacity-building initiatives for healthcare workers, are essential for reducing the malaria

burden in regions. Additionally, the generalizability of this study's findings is somewhat limited by the relatively small sample size and hospital-based design, which may not fully reflect community-level prevalence or diagnostic outcomes. Future research should aim to include larger, more representative samples and explore the effectiveness of diagnostic tools in community settings.

CONCLUSION

In conclusion, the sensitivity and specificity of RDTs was found to be 20% and 80% respectively, while microscopy had sensitivity and specificity of 75% and 81.3%. There prevalence of malaria parasitemia among adults with anemia was found to be 27.3%. While anemic children had a higher prevalence of 44.4%. The State Ministry of health should make efforts to access improved diagnostic strategies and malaria eradication strategies should include concurrent management of anemia. Also, there is a need for the improvement of logistic systems for drug and consumables in the state.

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