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Rapid Diagnostic Tests for Malaria in Remote Endemic Areas: Sensitivity, Specificity, and Treatment Decision Accuracy

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ABSTRACT

Malaria remained a leading cause of morbidity and mortality in remote endemic regions where access to quality microscopy is severely limited. Rapid diagnostic tests had revolutionized case management by enabling parasitological confirmation at the point of care, supporting the global shift from presumptive treatment to evidence-based antimalarial prescribing. Over 400 million RDTs were distributed annually, yet diagnostic performance and treatment decision accuracy vary substantially across operational contexts. This narrative review examined the technical principles underlying malaria RDTs, evaluated their diagnostic accuracy across diverse clinical and epidemiological settings, assessed operational challenges in remote areas, and analyzed the impact of RDT implementation on treatment decisions and patient outcomes. A comprehensive narrative synthesis of diagnostic accuracy studies, systematic reviews, field implementation research, and policy documents was conducted to evaluate RDT performance and clinical utility in resource-limited settings. Contemporary RDTs demonstrated excellent sensitivity (95% or higher) for detecting Plasmodium falciparum at parasitemia levels above 100 parasites per microliter, though performance declines substantially at lower densities and for non-falciparum species. Specificity generally exceeded 90% but is compromised by persistent HRP2 antigenemia following treatment and emerging pfhrp2/3 gene deletions. Operational challenges, including heat exposure, inadequate training, and supply chain disruptions, significantly impacted field performance. Health worker adherence to negative RDT results remained suboptimal in many settings, with antimalarial overtreatment persisting due to clinical pressure, diagnostic mistrust, and perverse incentives. RDTs represented essential tools for malaria case management in remote areas but required robust quality assurance, comprehensive training, and health systems strengthening to realize their full potential for improving treatment accuracy and patient outcomes.

Keywords: Malaria diagnosis, Rapid diagnostic tests, Sensitivity, Specificity, Point-of-care diagnostics

INTRODUCTION

Accurate malaria diagnosis represents a cornerstone of effective case management, enabling targeted antimalarial therapy while preventing unnecessary treatment and preserving drug efficacy [1, 2, 3-6]. Historically, malaria control programs relied on clinical diagnosis based on fever and associated symptoms, leading to massive antimalarial overuse given the nonspecific nature of febrile presentations in endemic areas. Studies from sub-Saharan Africa consistently demonstrated that 50% to 80% of presumptively treated febrile patients lacked parasitological evidence of malaria, resulting in missed diagnoses of alternative febrile illnesses, squandered antimalarial resources, and accelerated drug resistance development [3,7-11]. Recognition of these deficiencies prompted the World Health

Organization to adopt universal parasitological confirmation policies in 2010, establishing "test, treat, track" as the foundation for contemporary malaria case management.

Light microscopy has long served as the reference standard for malaria diagnosis, offering species identification, quantification of parasitemia, and detection of mixed infections [4,12-16]. However, quality microscopy requires trained microscopists, functional microscopes, reliable electricity, consumable supplies, and quality assurance systems that remain inaccessible to the majority of health facilities in malaria-endemic regions. Majority of at-risk populations in sub-Saharan Africa lack access to facilities capable of providing quality microscopy, creating enormous diagnostic gaps particularly in remote rural areas where malaria burden is highest [5, 6,17-23]. Rapid diagnostic tests emerged to address this access barrier, providing parasitological confirmation through simple immunochromatographic devices requiring minimal training, no electricity, and producing results within 15 to 20 minutes. Since their introduction in the 1990s and subsequent scale-up beginning in the mid-2000s, RDT deployment has expanded dramatically with over 400 million tests distributed globally in 2022, fundamentally transforming diagnostic capacity in previously underserved regions [24-28].

Despite this remarkable expansion, questions persist regarding RDT diagnostic accuracy in real-world conditions, particularly sensitivity for low-density parasitemia and non-falciparum species, specificity in the context of persistent antigenemia, and operational performance when tests are exposed to heat stress and implemented by minimally trained health workers [29-35]. Furthermore, the pathway from diagnostic test results to appropriate treatment decisions proves complex, mediated by health worker training, diagnostic confidence, clinical pressure from patients and communities, drug availability, and perverse incentives favoring antimalarial prescription. This review systematically examines the immunological and biochemical principles underlying RDT technology, evaluates diagnostic performance characteristics across diverse clinical contexts and parasite species, assesses operational challenges specific to remote endemic settings, analyzes the impact of RDT availability on treatment decision-making patterns and clinical outcomes, and explores emerging diagnostic challenges and innovations shaping the future of malaria case management. The purpose of this synthesis is to provide clinicians, laboratory specialists, and program managers with an evidence-based assessment of RDT capabilities and limitations to inform diagnostic strategies optimized for remote endemic areas.

Principles of Malaria RDT Technology and Target Antigens

Malaria RDTs employ lateral flow immunochromatography, a technology analogous to pregnancy tests, to detect parasite-specific antigens in whole blood, plasma, or serum samples [7, 8,36-40]. The fundamental design involves a nitrocellulose membrane strip containing three key zones: a sample application pad where blood is added, a conjugate pad containing labeled antibodies specific for target antigens, and a detection zone containing immobilized capture antibodies that bind antigen-antibody complexes to generate visible test lines. When blood is applied and followed by a buffer solution, capillary action draws the sample along the membrane. If target antigens are present, they bind to the labeled antibodies in the conjugate pad, and this complex is subsequently captured at the test line, producing a visible colored band. A control line containing antibodies that bind the labeled antibodies regardless of antigen presence ensures test validity by confirming proper flow and reagent function.

Contemporary RDTs target three principal parasite antigens, each with distinct biological characteristics affecting diagnostic performance. Histidine-rich protein 2 (HRP2) is a water-soluble protein abundant in the cytoplasm and on the surface of Plasmodium falciparum asexual blood stages and young gametocytes [9, 10,41-44]. The protein is released into circulation upon schizont rupture and persists in blood for days to weeks following parasite clearance, enabling detection during and after treatment. This persistence provides a diagnostic advantage for recent infections but creates specificity challenges by producing positive results in successfully treated patients. Importantly, P. falciparum expresses a homologous protein (HRP3) that cross-reacts with HRP2 antibodies, providing redundancy but also creating vulnerability to dual gene deletions that abolish detectability.

Plasmodium lactate dehydrogenase (pLDH) is a glycolytic enzyme produced by all Plasmodium species during their asexual blood stage development [11,45-48]. Unlike HRP2, pLDH is cleared rapidly from circulation following parasite elimination, typically within 24 to 48 hours, making it suitable for distinguishing active infections from recently treated cases. Parasite LDH isoforms differ sufficiently from human LDH to enable specific detection, and sequence variation among Plasmodium species allows development of species-specific or pan-specific pLDH antibodies. However, pLDH abundance in parasites is lower than HRP2, resulting in reduced analytical sensitivity, particularly for low-density infections.

Aldolase, another glycolytic enzyme, is conserved across Plasmodium species and serves as a pan-malarial target [12,49-53]. Like pLDH, aldolase is cleared rapidly following parasite elimination and is present at moderate concentrations in parasitized erythrocytes. Aldolase-based tests show intermediate sensitivity between HRP2 and pLDH tests but provide broad species coverage useful for detecting non-falciparum infections.

RDT formats vary based on target antigen combinations and species detection capabilities. Two-band tests detect only P. falciparum (typically using HRP2), providing simple positive or negative results suited for areas with overwhelming falciparum predominance. Three-band combination tests incorporate both HRP2 and pan-malarial

targets (pLDH or aldolase), enabling differentiation of P. falciparum from non-falciparum species, including P. vivax, P. ovale, P. malariae, and P. knowlesi. This differentiation proves clinically important because P. vivax requires additional treatment with primaquine for radical cure of liver hypnozoites, and accurate species identification guides appropriate therapeutic selection. Four-band tests add P. vivax-specific pLDH detection, providing separate identification of P. falciparum, P. vivax, and other species, though these more complex formats show higher invalid rates in field conditions.

Test sensitivity depends fundamentally on antigen concentration, which correlates with parasite density. At parasitemia levels above 100 to 200 parasites per microliter, HRP2-based RDTs demonstrate sensitivities exceeding 95% compared to expert microscopy [13, 14,54-56]. This density-dependent detection creates clinical implications because low-density infections, while potentially asymptomatic, can progress to symptomatic disease and contribute to transmission, particularly in low-endemic areas approaching elimination.

Diagnostic Performance of RDTs: Sensitivity and Specificity Across Clinical Contexts

Systematic reviews and meta-analyses evaluating RDT diagnostic performance against reference standards reveal substantial heterogeneity based on parasite species, test brand, parasitemia level, and clinical population studied. For P. falciparum detection using HRP2-based tests, pooled sensitivity estimates consistently exceed 95% when restricting analysis to symptomatic patients with parasitemia above 100 parasites per microliter [15,57-58], approaching the theoretical performance of expert microscopy under optimal conditions. Specificity estimates generally range from 85% to 95%, with false positives arising from persistent HRP2 antigenemia in recently treated patients, cross-reactions in some test brands, and user interpretation errors, particularly with faint test lines.

Performance characteristics vary substantially across RDT brands despite WHO prequalification requirements. The WHO/FIND product testing program, which evaluates commercially available RDTs under standardized laboratory conditions, documented sensitivities ranging from 50% to 100% and specificities from 85% to 100% across different products at 200 parasites per microliter, highlighting marked quality variation in the RDT marketplace [16]. Lower-performing products typically failed to meet WHO procurement standards, yet some continue circulating in endemic countries through unregulated supply chains, underscoring the importance of national regulatory oversight and adherence to WHO-prequalified product lists.

Non-falciparum species present greater diagnostic challenges. RDT sensitivity for P. vivax detection using pLDH or aldolase targets typically ranges from 80% to 95% at densities above 500 parasites per microliter but declines to 50% to 75% at lower densities common in asymptomatic infections [17]. This reduced sensitivity reflects both lower antigen abundance compared to HRP2 and inherently lower parasitemia in many vivax infections. Importantly, P. vivax predominates in low-transmission settings across Asia, the Americas, and the Horn of Africa where low-density infections are epidemiologically significant for transmission maintenance and where diagnostic gaps have greater elimination implications. False negative RDT results for P. vivax can lead to treatment denial, missed opportunities for transmission interruption, and continuation of hypnozoite reservoirs perpetuating relapses.

Operational Challenges in Remote Endemic Settings

Implementation of RDT-based diagnostic strategies in remote endemic areas confronts multiple operational barriers that substantially impact the translation of laboratory-proven diagnostic accuracy into real-world clinical utility. These challenges span supply chain management, human resource capacity, infrastructure limitations, and quality assurance systems.

Heat stability represents one of the most critical technical constraints. RDT reagents including antibodies and conjugates are temperature-sensitive biological materials that degrade when exposed to elevated temperatures, resulting in progressive sensitivity loss and increased invalid rates [18]. Manufacturer specifications typically recommend storage at 2°C to 30°C, but maintaining this cold chain proves extraordinarily challenging in tropical endemic regions where ambient temperatures frequently exceed 35°C and electricity for refrigeration is unreliable or absent at peripheral health facilities. Studies using heat stability monitors have documented that RDTs commonly experience temperature excursions during multi-stage distribution from central warehouses to district stores to health facilities, with some test lots spending weeks or months in uncontrolled temperature conditions before reaching end users.

Supply chain management challenges extend beyond temperature control to encompass forecasting, procurement, distribution, and inventory management [19]. Chronic stock-outs of RDTs at peripheral facilities undermine diagnostic coverage, forcing reversion to presumptive treatment and eroding health worker and community confidence in diagnostic protocols [20]. Conversely, overstocking leads to expiration of tests before use, representing wastage of scarce resources. Many national malaria programs lack robust supply chain information systems capable of tracking RDT availability at facility level and triggering timely redistribution or emergency resupply. Integration of RDT supply chains with broader pharmaceutical logistics systems offers potential efficiencies but requires coordination across organizational boundaries and information systems that frequently do not communicate effectively.

Human resource constraints profoundly impact RDT implementation quality. While RDTs are designed for use by minimally trained personnel, achieving reliable performance requires initial training on proper test execution, quality control, interpretation of results including faint test lines, and recording of findings. Training coverage remains inadequate in many settings, with rapid staff turnover at peripheral facilities necessitating continuous retraining that health systems struggle to provide. Supportive supervision, recognized as essential for maintaining competence and identifying performance problems, occurs infrequently if at all in remote areas due to transportation challenges, competing priorities, and inadequate supervisory resources. The result is that many health workers receive only cursory initial training, never encounter supervisory visits, and develop idiosyncratic practices that compromise diagnostic accuracy. Studies using competency checklists to observe RDT performance by health workers document error rates for critical steps including blood volume addition, buffer application, and timing of result reading [21].

Quality assurance systems for RDTs remain underdeveloped in most endemic countries despite WHO recommendations for external quality assessment programs. Unlike microscopy, for which proficiency testing through slide rechecking is well established, RDT quality assurance faces technical challenges related to the binary nature of test results, absence of specimens for retesting once blood is applied, and difficulties standardizing positive control materials. Some programs have implemented panel testing using recombinant antigens or cultured parasites, but coverage remains limited and does not assess point-of-care performance under actual field conditions. Routine monitoring of invalid rates, calculated from facility registers as the proportion of tests yielding no control line, provides a simple quality indicator but requires data systems capable of aggregating facility-level information and triggering investigations when thresholds are exceeded.

Infrastructure limitations at peripheral health facilities compound these operational challenges. Many remote health posts lack clean running water for handwashing before and after blood collection, surfaces suitable for test performance, adequate lighting for result interpretation, secure storage areas protecting tests from theft or environmental damage, and functional waste disposal systems for contaminated materials. The cumulative effect of these deficiencies creates conditions where even well-trained health workers struggle to perform RDTs according to proper protocols.

Impact of RDTs on Treatment Decision-Making and Clinical Outcomes

The ultimate objective of diagnostic testing is to improve clinical decision-making and patient outcomes. According to the WHO, RDT availability has demonstrably increased the proportion of malaria-suspected cases receiving parasitological confirmation [22]. This represents a fundamental transformation in case management practices driven primarily by RDT scale-up rather than microscopy expansion.

However, the relationship between test availability and treatment appropriateness proves more complex than initially anticipated. Clinical uncertainty about RDT reliability, particularly among providers who distrust test accuracy or suspect false negatives, leads to empiric treatment based on clinical judgment. Patient and community expectations for antimalarial medications when presenting with fever create pressure on health workers to prescribe despite negative results, particularly in contexts where refusing treatment may generate complaints or accusations of poor care quality [23]. Perverse incentives, including revenue generation from drug sales at private facilities or informal fees for injections, create financial motivation for overtreatment. Inadequate training on the interpretation and management of negative results leaves health workers uncertain about alternative diagnoses and appropriate treatments for non-malarial febrile illnesses.

The public health consequences of antimalarial overtreatment include unnecessary drug expenditure, perpetuation of diagnostic nihilism undermining test credibility, opportunity costs from missed treatment of actual illness causes, and contributions to antimalarial resistance development, particularly for artemisinin-based combination therapies. Recognition of these adherence challenges has prompted interventions targeting provider behavior through enhanced training emphasizing negative result management, clinical algorithms for febrile illness evaluation, community sensitization about appropriate antimalarial use, and removal of perverse financial incentives [24]. Evaluation studies demonstrate that comprehensive interventions combining multiple components can improve adherence to negative results substantially, though sustaining improvements requires ongoing reinforcement.

Conversely, undertreatment of true malaria cases due to false-negative RDT results represents the complementary risk. While less common than overtreatment of negatives in most settings, given the high sensitivity of HRP2-based tests for symptomatic P. falciparum malaria, false negatives occur with meaningful frequency for non-falciparum species, low-density infections, and when using lower-quality test brands or degraded test lots [25]. False negatives can result in treatment denial, symptom persistence, disease progression, and preventable deaths, particularly when patients fail to return for reevaluation. Guidelines recommend that patients with negative RDT results but persistent or worsening symptoms receive clinical reassessment and possible empiric treatment or referral, but implementation of this safety net proves inconsistent in routine practice.

The impact of RDT implementation on overall malaria case management quality shows mixed evidence. Controlled trials in high-quality research settings consistently demonstrate that RDT availability reduces antimalarial

prescribing compared to clinical diagnosis, with higher reductions observed across multiple studies, while maintaining or improving identification and treatment of confirmed malaria cases [26]. Health facility outcomes, including mortality and severe malaria incidence, show no worsening with RDT-based management in most evaluations, providing reassurance about patient safety. However, observational studies from routine program implementation reveal more modest impacts, with smaller reductions in overtreatment and persistent high rates of antimalarial use, suggesting that effectiveness in real-world conditions falls short of efficacy demonstrated in controlled research contexts.

An underappreciated dimension of diagnostic impact concerns management of RDT-negative febrile patients. Availability of malaria testing creates opportunities to correctly identify and treat alternative causes of fever, including bacterial infections, viral illnesses, and non-infectious conditions. However, many health facilities lack diagnostic capacity for these alternative diagnoses, and health workers receive insufficient training in non-malarial febrile illness management. Studies document that RDT-negative patients frequently receive no treatment, inappropriate antibiotics are prescribed empirically without indication, or symptomatic treatment alone when specific therapy is warranted. Strengthening integrated management of febrile illness through enhanced diagnostic algorithms, improved access to complementary tests, and comprehensive training represents a critical need for realizing the full potential of malaria diagnostic investments.

Emerging Challenges and Future Directions in Malaria Diagnostics

The diagnostic landscape for malaria continues evolving in response to biological, technological, and epidemiological shifts that pose both challenges and opportunities for case management in remote endemic areas.

Plasmodium falciparum parasites carrying deletions of the pfhrp2 and pfhrp3 genes represent an emerging threat to RDT-based diagnosis [27]. These parasites cannot produce HRP2 or HRP3 proteins, rendering them undetectable by HRP2-based RDTs despite causing symptomatic disease. First documented in Peru in the 1990s, pfhrp2-deleted parasites have now been confirmed in multiple countries across South America, Africa, including Eritrea, Djibouti, Ethiopia, Rwanda, and parts of the Horn of Africa, and potentially elsewhere [28]. Prevalence of pfhrp2 varies geographically from under 5% to over 80% of parasites in some Eritrean regions, creating scenarios where HRP2-based RDTs miss the majority of infections [29, 30]. The mechanisms driving deletion emergence and spread remain incompletely understood but likely involve selection pressure from widespread HRP2-based RDT use combined with reduced fitness costs of gene deletion. The expansion of deletions represents a sobering reminder of pathogen adaptability and the potential for diagnostic tools to become obsolete through evolutionary escape.

Ultra-sensitive RDTs capable of detecting parasitemia below conventional RDT thresholds are under development to address requirements of elimination programs targeting asymptomatic low-density infections that sustain transmission [31]. These next-generation tests employ signal amplification technologies, alternative assay formats, or novel biomarkers to achieve tenfold or greater sensitivity improvements compared to current products. However, translation from prototype to field-deployable product faces challenges, including cost, complexity, stability, and uncertain clinical utility given ongoing debates about treatment indications for submicroscopic infections. Nevertheless, ultra-sensitive diagnostics may prove valuable for focal screening and treatment interventions in low-endemic areas pursuing elimination.

Multiplex diagnostic platforms capable of simultaneously detecting multiple pathogens causing febrile illness represent an aspirational goal for improving syndrome-based case management. Prototype devices combining malaria detection with tests for bacterial infections, dengue, Zika, chikungunya, and other endemic pathogens have been developed, offering potential for comprehensive differential diagnosis at the point of care [32, 33]. However, technical complexity, cost per test, and requirements for equipment infrastructure currently limit deployment to reference laboratories rather than peripheral health facilities. As technologies mature and costs decline, multiplex diagnostics may eventually transform febrile illness management in resource-limited settings.

Digital connectivity integrated with RDT platforms offers opportunities for strengthening case surveillance, quality assurance, and supply chain management [34, 35]. RDT readers equipped with cameras and interpretation algorithms can capture test images for remote quality control, transmit results to centralized databases in real time, and provide decision support to health workers. Evaluation studies demonstrate feasibility and potential impact, but implementation at scale requires investment in devices, mobile network coverage, data systems, and maintenance support that exceed current program budgets in most endemic countries.

Alternative diagnostic technologies, including loop-mediated isothermal amplification (LAMP) and clustered regularly interspaced short palindromic repeats (CRISPR)-based nucleic acid detection, show promise for filling performance gaps between RDTs and PCR [36, 37]. LAMP assays provide PCR-comparable sensitivity with simpler equipment requirements, potentially suitable for district laboratories serving networks of peripheral health facilities. CRISPR-based diagnostics combine high sensitivity and specificity with potential for a point-of-care format, though development for malaria detection remains at early stages. These technologies may eventually enable tiered diagnostic networks where ultra-sensitive molecular testing at intermediate facilities complements RDT-

based screening at peripheral sites, optimizing the balance between accessibility, accuracy, and cost across the health system.

CONCLUSION

Rapid diagnostic tests have fundamentally transformed malaria case management in remote endemic areas by democratizing access to parasitological confirmation previously available only through microscopy at higher-level facilities. Contemporary HRP2-based RDTs demonstrate excellent sensitivity and specificity for detecting symptomatic Plasmodium falciparum malaria at parasitemia levels associated with clinical disease, providing a robust foundation for evidence-based antimalarial prescribing that reduces overtreatment while maintaining effective coverage of confirmed cases. However, significant performance limitations persist including reduced sensitivity for non-falciparum species and low-density infections, specificity challenges from persistent antigenemia and emerging pfhrp2 deletions, and field performance degradation due to heat exposure and operational weaknesses. The translation of diagnostic test results into appropriate treatment decisions remains incomplete, with substantial antimalarial prescription for RDT-negative patients reflecting complex behavioral, systemic, and contextual factors that resist simple technical solutions. Operational challenges specific to remote settings, including supply chain fragility, human resource constraints, infrastructure deficiencies, and weak quality assurance systems, substantially impair the realization of RDT potential demonstrated under controlled research conditions. Emerging diagnostic challenges including gene deletion spread and evolving elimination requirements, necessitate continued innovation in diagnostic technologies, surveillance systems, and implementation strategies. Maximizing the contribution of RDTs to malaria control and elimination requires comprehensive approaches integrating product quality assurance, robust supply chains, competency-based training with supportive supervision, health systems strengthening for integrated febrile illness management, and adaptive diagnostic strategies responsive to changing epidemiological and biological contexts. The future diagnostic landscape will likely feature diversified tools, including next-generation RDTs, ultra-sensitive platforms for elimination settings, multiplex diagnostics for comprehensive differential diagnosis, and digital connectivity enabling real-time surveillance and quality monitoring. Achieving this vision demands sustained investment, political commitment, and technical innovation to ensure that all individuals with suspected malaria receive accurate, timely diagnosis, enabling optimal treatment and outcomes regardless of geographic location or resource availability.

National malaria programs should establish comprehensive diagnostic quality assurance systems encompassing WHO-prequalified product procurement, cold chain monitoring throughout distribution networks, competency-based training with regular refresher courses, routine lot testing of RDT shipments, facility-level invalid rate surveillance with investigation thresholds, and integration of RDT supply management within strengthened pharmaceutical logistics platforms to ensure reliable diagnostic performance supporting appropriate treatment decisions in remote endemic areas.

REFERENCES

1. Abdul-Rahman, T., Ajetunmobi, O.A., Bamigbade, G.B., Ayesiga, I., Shah, M.H., Rumide, T.S., Adesina, A.B., Adeshina, G.A., Oni, O.E., Christian, B.N., Aborode, A.T., Wireko, A.A., Thaalibi, H.I., Abdalla, I.M., Banimusa, S.B., Jonathan, J.N., Onifade, I.A., Haque, M.A.: Improving diagnostics and surveillance of malaria among displaced people in Africa. Int J Equity Health. 24, 22 (2025). https://doi.org/10.1186/s12939-025-02378-6
2. Ogbonnia Egwu, C., Aloke, C., Chukwu, J., Agwu, A., Tsamesidis, I., M Aja, P., E Offor, C., Ajuka Obasi, N.: A world free of malaria: It is time for Africa to actively champion and take leadership of elimination and eradication strategies. Afr H. Sci. 22, 627–640 (2022). https://doi.org/10.4314/ahs.v22i4.68
3. Nansseu, J.R.N., Noubiap, J.J.N., Ndoula, S.T., Zeh, A.F.M., Monamele, C.G.: What is the best strategy for the prevention of transfusion-transmitted malaria in sub-Saharan African countries where malaria is endemic? Malar J. 12, 465 (2013). https://doi.org/10.1186/1475-2875-12-465
4. Calderaro, A., Piccolo, G., Chezzi, C., Calderaro, A., Piccolo, G., Chezzi, C.: The Laboratory Diagnosis of Malaria: A Focus on the Diagnostic Assays in Non-Endemic Areas. International Journal of Molecular Sciences. 25, (2024). https://doi.org/10.3390/ijms25020695
5. Golumbeanu, M., Edi, C.A.V., Hetzel, M.W., Koepfli, C., Nsanzabana, C.: Bridging the Gap from Molecular Surveillance to Programmatic Decisions for Malaria Control and Elimination. Am J Trop Med Hyg. 112, 35–47 (2025). https://doi.org/10.4269/ajtmh.22-0749
6. Tufail, T., Agu, P.C., Akinloye, D.I., Obaroh, I.O.: Malaria pervasiveness in Sub-Saharan Africa: Overcoming the scuffle. Medicine (Baltimore). 103, e40241 (2024). https://doi.org/10.1097/MD.0000000000040241
7. Njeru, A.W.: Performance of Rapid Immunochromatographic Test And The Effect Of Age And Parity on Malaria Infection among Expectant Women in Kericho County.
8. Kavanaugh, M.J., Azzam, S.E., Rockabrand, D.M.: Malaria Rapid Diagnostic Tests: Literary Review and Recommendation for a Quality Assurance, Quality Control Algorithm. Diagnostics (Basel). 11, 768 (2021). https://doi.org/10.3390/diagnostics11050768

9. Nyataya, J., Waitumbi, J., Mobegi, V.A., Noreddin, A., El Zowalaty, M.E.: Plasmodium falciparum Histidine-Rich Protein 2 and 3 Gene Deletions and Their Implications in Malaria Control. Diseases. 8, 15 (2020). https://doi.org/10.3390/diseases8020015
10. Willie, N.: Plasmodium falciparum Histidine-rich Protein 2 Gene Variation and Malaria Detection in Madagascar and Papua New Guinea, https://etd.ohiolink.edu/acprod/odb_etd/etd/r/1501/10?clear=10&p10_accession_num=case1519326080906088, (2018)
11. Cao, P., Kho, S., Grigg, M.J., Barber, B.E., Piera, K.A., William, T., Poespoprodjo, J.R., Jang, I.K., Simpson, J.A., McCaw, J.M., Anstey, N.M., McCarthy, J.S., Britton, S.: Characterisation of Plasmodium vivax lactate dehydrogenase dynamics in P. vivax infections. Commun Biol. 7, 355 (2024). https://doi.org/10.1038/s42003-024-05956-6
12. Dzakah, E.E., Kang, K., Ni, C., Wang, H., Wu, P., Tang, S., Wang, J., Wang, J., Wang, X.: Plasmodium vivax aldolase-specific monoclonal antibodies and its application in clinical diagnosis of malaria infections in China. Malar J. 12, 199 (2013). https://doi.org/10.1186/1475-2875-12-199
13. Kyabayinze, D.J., Zongo, I., Cunningham, J., Gatton, M., Angutoko, P., Ategeka, J., Compaoré, Y.-D., Muehlenbachs, A., Mulondo, J., Nakalembe, M., Somé, F.A., Ouattara, A., Rouamba, N., Ouédraogo, J.-B., Hopkins, H., Bell, D.: HRP2 and pLDH-Based Rapid Diagnostic Tests, Expert Microscopy, and PCR for Detection of Malaria Infection during Pregnancy and at Delivery in Areas of Varied Transmission: A Prospective Cohort Study in Burkina Faso and Uganda. PLOS ONE. 11, e0156954 (2016). https://doi.org/10.1371/journal.pone.0156954
14. Awosolu, O.B., Yahaya, Z.S., Haziqah, M.T.F., Olusi, T.A., Awosolu, O.B., Yahaya, Z.S., Haziqah, M.T.F., Olusi, T.A.: Performance Evaluation of Nested Polymerase Chain Reaction (Nested PCR), Light Microscopy, and Plasmodium falciparum Histidine-Rich Protein 2 Rapid Diagnostic Test (PfHRP2 RDT) in the Detection of Falciparum Malaria in a High-Transmission Setting in Southwestern Nigeria. Pathogens. 11, (2022). https://doi.org/10.3390/pathogens11111312
15. Turnbull, L.B., Ayodo, G., Knight, V., John, C.C., McHenry, M.S., Tran, T.M.: Evaluation of an ultrasensitive HRP2–based rapid diagnostic test for detection of asymptomatic Plasmodium falciparum parasitaemia among children in western Kenya. Malar J. 21, 337 (2022). https://doi.org/10.1186/s12936-022-04351-y
16. Gatton, M.: Malaria rapid diagnostic test performance: Results of WHO product testing of malaria RDTs: round 7 (2015-2016).
17. Barber, B.E., William, T., Grigg, M.J., Piera, K., Yeo, T.W., Anstey, N.M.: Evaluation of the Sensitivity of a pLDH-Based and an Aldolase-Based Rapid Diagnostic Test for Diagnosis of Uncomplicated and Severe Malaria Caused by PCR-Confirmed Plasmodium knowlesi, Plasmodium falciparum, and Plasmodium vivax. J Clin Microbiol. 51, 1118–1123 (2013). https://doi.org/10.1128/JCM.03285-12
18. Gomes, L., Tada, M., Katsuragawa, T., Povoa, M., Viana, G., Alecrim, M., Santana-Filho, F., Arcanjo, A., Couto, A., Calvosa, V., Nery, A., Fontes, C.: Low sensitivity of malaria rapid diagnostic tests stored at room temperature in the Brazilian Amazon Region. Journal of infection in developing countries. 7, 243–252 (2013). https://doi.org/10.3855/jidc.2564
19. Mezieobi, K.C., Egba, S.I., Ewah, C.M.: Economic burden of malaria on developing countries: A mini review. Parasite Epidemiology and Control. 30, e00435 (2025). https://doi.org/10.1016/j.parepi.2025.e00435
20. Miller, E., Sikes, H.D.: Addressing Barriers to the Development and Adoption of Rapid Diagnostic Tests in Global Health. Nanobiomedicine. 2, 2–6 (2015). https://doi.org/10.5772/61114
21. Ramani, S., Kohar, H.T., Pratt, O., Denon, Y.E., Reed, C.M., Thomas, P., Powell, S.E., Aidoo, M.: Stability testing of dried Plasmodium falciparum positive quality control samples for malaria rapid diagnostic tests in Liberia and Benin. Malar J. 19, 288 (2020). https://doi.org/10.1186/s12936-020-03364-9
22. Rapid diagnostic tests for malaria, https://www.who.int/teams/global-malaria-programme/case-management/diagnosis/rapid-diagnostic-tests
23. Ansah, E.K., Reynolds, J., Akanpigbiam, S., Whitty, C.J., Chandler, C.I.: "Even if the test result is negative, they should be able to tell us what is wrong with us": a qualitative study of patient expectations of rapid diagnostic tests for malaria. Malar J. 12, 258 (2013). https://doi.org/10.1186/1475-2875-12-258
24. Alum, E.U., Ainebyoona, C., Egwu, C.O., Onohuean, H., Ugwu, O.P.-C., Uti, D.E., Alum, B.N., Echegu, D.A.: Mitigation of Malaria in Sub-Saharan Africa through Vaccination: A Budding Road Map for Global Malaria Eradication. Ethiopian Journal of Health Sciences. 35, (2025)
25. Nolder, D., Stewart, L., Tucker, J., Ibrahim, A., Gray, A., Corrah, T., Gallagher, C., John, L., O'Brien, E., Aggarwal, D., Benavente, E.D., van Schalkwyk, D., Henriques, G., Sepúlveda, N., Campino, S., Chiodini, P., Sutherland, C., Beshir, K.B.: Failure of rapid diagnostic tests in Plasmodium falciparum malaria cases among travelers to the UK and Ireland: Identification and characterisation of the parasites. Int J Infect Dis. 108, 137–144 (2021). https://doi.org/10.1016/j.ijid.2021.05.008

26. Odaga, J., Sinclair, D., Lokong, J.A., Donegan, S., Hopkins, H., Garner, P.: Rapid diagnostic tests versus clinical diagnosis for managing people with fever in malaria endemic settings. Cochrane Database Syst Rev. 2014, CD008998 (2014). https://doi.org/10.1002/14651858.CD008998.pub2
27. Mediavilla, A., Molina-de la Fuente, I., Martínez-Vallejo, P., Francisco, K., Martins, J.F., Febrer-Sendra, B., Maturana, C.R., Silgado, A., Nindia, A., Goterris, L., Martínez-Campreciós, J., Oliveira-Souto, I., Molina, I., Berzosa, P., Sulleiro, E.: Analysis of pfhrp2 and pfhrp3 gene deletions, and the structure and variability of PfHRP2 and PfHRP3 proteins: implications for the performance of malaria rapid diagnostic tests in Cubal, Angola. Malar J. 24, 296 (2025). https://doi.org/10.1186/s12936-025-05523-2
28. Rogier, E., McCaffery, J.N., Nace, D., Svigel, S.S., Assefa, A., Hwang, J., Kariuki, S., Samuels, A.M., Westercamp, N., Ratsimbasoa, A., Randrianarivelojosia, M., Uwimana, A., Udhayakumar, V., Halsey, E.S.: Plasmodium falciparum pfhrp2 and pfhrp3 Gene Deletions from Persons with Symptomatic Malaria Infection in Ethiopia, Kenya, Madagascar, and Rwanda. Emerg Infect Dis. 28, 608–616 (2022). https://doi.org/10.3201/eid2803.211499
29. Mihreteab, S., Anderson, K., Pasay, C., Smith, D., Gatton, M.L., Cunningham, J., Berhane, A., Cheng, Q.: Epidemiology of mutant Plasmodium falciparum parasites lacking histidine-rich protein 2/3 genes in Eritrea 2 years after switching from HRP2-based RDTs. Sci Rep. 11, 21082 (2021). https://doi.org/10.1038/s41598-021-00714-8
30. Mihreteab, S., Anderson, K., Fuente, I.M. la, Sutherland, C.J., Smith, D., Cunningham, J., Beshir, K.B., Cheng, Q.: The spread of a validated molecular marker of artemisinin partial resistance pfkelch13 R622I and association with pfhrp2/3 deletions in Eritrea, https://www.medrxiv.org/content/10.1101/2023.10.20.23297302v1, (2023)
31. Zainabadi, K.: Ultrasensitive Diagnostics for Low-Density Asymptomatic Plasmodium falciparum Infections in Low-Transmission Settings. Journal of Clinical Microbiology. 59, 10.1128/jcm.01508-20 (2021). https://doi.org/10.1128/jcm.01508-20
32. Shang, M., Guo, J., Guo, J.: Point-of-care testing of infectious diseases: recent advances. Sensors & Diagnostics. 2, 1123–1144 (2023). https://doi.org/10.1039/D3SD00092C
33. Puig, H. de, Bosch, I., Collins, J.J., Gehrke, L.: Point-of-Care Devices to Detect Zika and Other Emerging Viruses. Annual Review of Biomedical Engineering. 22, 371–386 (2020). https://doi.org/10.1146/annurev-bioeng-060418-052240
34. Ugwu, O.P.-C., Alum, E.U., Ugwu, J.N., Eze, V.H.U., Ugwu, C.N., Ogenyi, F.C., Okon, M.B.: Harnessing technology for infectious disease response in conflict zones: Challenges, innovations, and policy implications. Medicine. 103, e38834 (2024). https://doi.org/10.1097/MD.0000000000038834
35. Boateng, K.A.: Digital Technology Adoption, Supply Chain Integration, Supply Chain Transparency, Supply Chain Traceability In Ghana's Health Sector, http://ir.ucc.edu.gh/jspui/handle/123456789/11638, (2024)
36. Chakraborty, S.: Democratizing nucleic acid-based molecular diagnostic tests for infectious diseases at resource-limited settings – from point of care to extreme point of care. Sensors & Diagnostics. 3, 536–561 (2024). https://doi.org/10.1039/D3SD00304C
37. Yang, N., Zhang, H., Han, X., Liu, Z., Lu, Y.: Advancements and applications of loop-mediated isothermal amplification technology: a comprehensive overview. Front. Microbiol. 15, (2024). https://doi.org/10.3389/fmicb.2024.1406632
38. Ugwu OPC. Anti-malaria effect of ethanol extract of Moringa oleifera (Agbaji) leaves on malaria induced mice [thesis]. Nsukka: University of Nigeria; 2011.
39. Obeagu EI, Alum EU, Ugwu OPC. Hepcidin: the gatekeeper of iron in malaria resistance. Newport Int J Res Med Sci. 2023;4(2):1–8.
40. Obeagu EI, Alum EU, Ugwu OPC. Hepcidin's antimalarial arsenal: safeguarding the host. Newport Int J Public Health Pharm. 2023;4(2):1–8.
41. Alum EU, Ainebyoona C, Egwu CO, Onohuean H, Ugwu OPC, Uti DE, et al. Mitigation of malaria in Sub-Saharan Africa through vaccination: a budding road map for global malaria eradication. Ethiop J Health Sci. 2025;35(3).
42. Mezieobi KC, Alum EU, Ugwu OPC, Uti DE, Alum BN, Egba SI, et al. Economic burden of malaria on developing countries: a mini review. Parasite Epidemiol Control. 2025;30:e00435.
43. Obeagu EI, Byukusenge C. Placental malarial infection: a review. Newport Int J Res Med Sci. 2023;3(2):1–5.
44. Alum EU, Ugwu OPC, Egba SI, Uti DE, Alum BN. Climate variability and malaria transmission: unraveling the complex relationship. INOSR Sci Res. 2024;11(2):16–22.
45. Okechukwu P, Ossai D, Tukur G, Eze O, Ekwueme OC. Bacteriuria and urinary schistosomiasis in primary school children in rural communities in Enugu State, Nigeria. Pan Afr Med J. 2014;18:15.

46. Obeagu EI, Nimo OM, Bunu UO, Ugwu OPC, Alum EU. Anaemia in children under five years: African perspectives. Int J Curr Res Biol Med. 2023;8(1):1–7.

47. Obeagu EI, Ali MM, Alum EU, Obeagu GU, Ugwu OPC, Bunu UO. An update of anaemia in adults with heart failure. Int Netw Organ Sci Res. 2023.

48. Obeagu EI, Obeagu GU, Igwe MC, Alum EU, Ugwu OPC. Men's essential roles in the management of sickle cell anemia. Newport Int J Sci Exp Sci. 2023;4(2).

49.Obeagu EI, Alum EU, Obeagu GU, Ugwu OPC. Lifestyle, genetics and sickle cell anemia: unveiling the interplay of risk factors. Int J Innov Appl Res. 2023;11(12):41–6.

50. Obeagu EI, Obeagu GU, Ugwu OPC. Navigating hemolysis in expectant mothers with sickle cell anemia: best practices and challenges. IAA J Appl Sci. 2024;11(1):30–9.

51. Obeagu EI, Omar DM, Bunu UO, Alum EU, Ugwu OPC. Leukaemia burden in Africa. Int J Curr Res Biol Med. 2023;8(1):17–22.

52. Obeagu EI, Ahmed YA, Obeagu GU, Bunu UO, Ugwu OPC, Alum EU. Biomarkers of breast cancer: overview. Int J Curr Res Biol Med. 2023;8(1):8–16.

53. Obeagu EI, Obeagu GU, Obiezu J, Ezeonwumelu C, Ogunnaya FU, Alum EU, et al. Immunomodulatory effects of transfusions on maternal immunity in pregnancy. Newport Int J Biol Appl Sci. 2023;3(3):1–8.

54. Obeagu EI, Obeagu GU, Alum EU, Ugwu OPC, Obiezu J, Ezeonwumelu C, et al. Antioxidants and pregnancy: impact on maternal and fetal health. Newport Int J Biol Appl Sci. 2023;4(1):17–25.

55. Obeagu EI, Ali AA, Onwuasoanya UF, Ngwoke AO, Vandu DC, Ugwu OPC, et al. Anaemia among pregnant women: a review in Africa. Int Digit Organ Sci Res. 2023.

56. Obeagu EI, Bot YS, Obeagu GU, Alum EU, Ugwu OPC. Anaemia and risk factors in lactating mothers: a concern in Africa. Int J Innov Appl Res. 2023;11(2):15–7.

57. Obeagu EI, Obeagu GU, Ugwu OPC, Alum EU. The role of antioxidants in improving pregnancy outcomes. IAA J Appl Sci. 2024;11(1):40–8.

58. Obeagu EI, Ugwu OPC. Prostate specific antigen levels on prostate disorders in south-east Nigeria. IAA J Sci Res. 2023;10(1):74–6.

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https://doi.org/10.59298/NIJSES/2026/72.116124