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Review on Role of Biomarkers and Aptamers in Malaria Diagnostics Advances

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ABSTRACT

Malaria continues to be a major public health concern in many tropical and subtropical regions, causing significant morbidity and mortality worldwide. Despite ongoing control measures, the emergence of drug-resistant Plasmodium species has complicated treatment strategies, creating an urgent need for novel therapeutic approaches. Recent research has explored innovative antimalarial agents, combination therapies, and targeted drug delivery systems to enhance treatment efficacy and overcome resistance. This review summarizes recent advancements in antimalarial drug development, focusing on new molecular targets, improved formulations, and combination regimens. The discussion also highlights the importance of integrating modern drug discovery techniques, such as structure-based design and high-throughput screening, to accelerate the development of effective, safe, and affordable antimalarial medicines.

Keywords: *Biomarkers, biosensors, early diagnosis, advances*

INTRODUCTION

Malaria remains one of the most significant infectious diseases affecting millions of people annually, particularly in resource-limited settings (World Health Organization [WHO], 2023). Caused by protozoan parasites of the genus *Plasmodium* and transmitted through the bite of infected *Anopheles* mosquitoes, the disease continues to cause substantial morbidity and mortality in tropical and subtropical regions (Snow et al., 2017). Although global initiatives have reduced malaria incidence and mortality in recent years, it still disproportionately affects vulnerable populations, including children and pregnant women, especially in Africa, Southeast Asia, and parts of South America (Bhatt et al., 2015).

The emergence and rapid spread of antimalarial drug resistance, particularly against agents such as chloroquine and artemisinin derivatives, have become a pressing global health concern (Ashley et al., 2014). Resistance not only reduces treatment efficacy but also complicates eradication efforts, making the development of new drugs essential. The evolution of multi-drug resistant strains has rendered several older therapies ineffective, necessitating constant surveillance and the adaptation of treatment guidelines (Noedl et al., 2008).

Recent advances in biomedical research have opened new opportunities for antimalarial drug discovery. Molecular biology, genomics, and proteomics have facilitated the identification of novel therapeutic targets within *Plasmodium* parasites (Cowman et al., 2016). Furthermore, advancements in medicinal chemistry and nanotechnology have improved drug delivery systems, enhancing bioavailability and reducing toxicity (Vyas et al., 2013). Such innovations are critical for addressing the growing challenge of resistance and ensuring long-term treatment success.

This review aims to provide an updated overview of the latest developments in antimalarial therapy, focusing on novel drug candidates, advanced formulations, and promising combination regimens. By compiling recent findings, it seeks to assist researchers and healthcare professionals in identifying emerging trends and potential strategies for effective management and eventual eradication of malaria.

Biomarkers identified for malaria diagnosis and treatment

Biomarkers play a crucial role in the diagnosis, prognosis, and therapeutic monitoring of malaria. These biological indicators, derived from host or parasite sources, can assist in early detection, assess disease severity, and evaluate treatment responses (Dhangadamajhi et al., 2010). Conventional malaria diagnosis has relied on microscopic examination of blood smears and rapid diagnostic tests (RDTs) targeting parasite antigens. However, these methods have limitations in sensitivity, particularly in cases of low parasitemia or mixed infections (Wongsrichanalai et al., 2007).

Recent advances in biomarker research have identified a range of promising molecular and immunological targets. Circulating parasite-derived proteins such as histidine-rich protein 2 (HRP2) and *Plasmodium lactate dehydrogenase* (pLDH) are widely used in RDTs and have shown good specificity, although HRP2 deletions in certain *P. falciparum* strains present diagnostic challenges (Gamboa et al., 2010). Additionally, host-derived biomarkers like C-reactive protein (CRP) and pro-inflammatory cytokines (e.g., TNF-α, IL-6) have been correlated with disease severity and may serve as prognostic indicators (Mahmood et al., 2011).

Emerging techniques such as proteomics, transcriptomics, and metabolomics are enabling the discovery of novel biomarker candidates for malaria. For instance, metabolomic profiling has revealed alterations in lipid and amino acid metabolism associated with malaria pathogenesis, which may offer new diagnostic avenues (Kamleh et al., 2008). Furthermore, the integration of biomarker panels with advanced detection platforms, including microfluidics and point-of-care biosensors, holds promise for improving diagnostic accuracy in field settings (Cheng et al., 2014).

The ongoing refinement and validation of malaria biomarkers are essential for enhancing disease surveillance, tailoring treatment strategies, and supporting elimination efforts. As research progresses, the development of cost-effective, rapid, and reliable biomarker-based diagnostics will be critical in combating malaria in endemic regions.

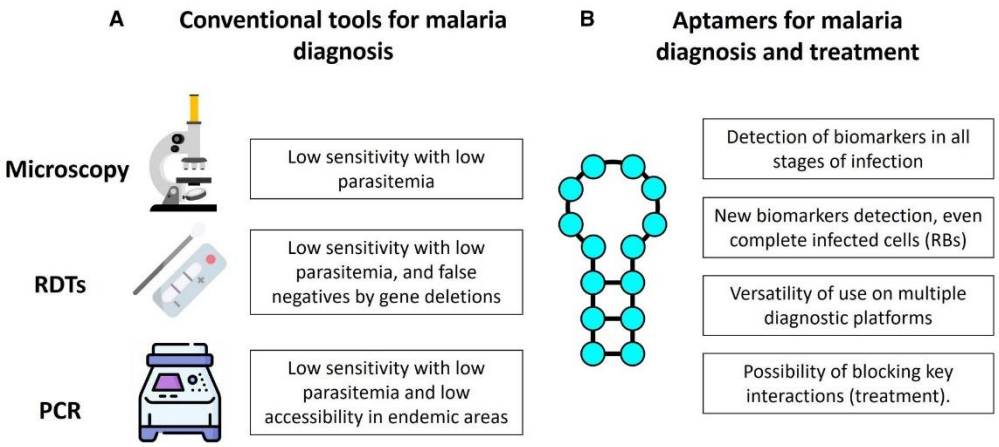
Adjunct Therapy

Adjunct therapies are increasingly being explored to complement standard antimalarial treatments, particularly in cases of severe malaria or drug resistance. These supportive approaches aim to reduce disease severity, prevent complications, and improve overall patient outcomes (Dondorp et al., 2010). While antimalarial drugs target the parasite directly, adjunctive strategies focus on modulating host-pathogen interactions, alleviating inflammation, and managing organ dysfunction.

One of the most studied adjunctive interventions is the use of artesunate in combination with parenteral antibiotics for the management of severe malaria with suspected bacterial co-infections (Reyburn et al., 2004). Additionally, anti-inflammatory agents such as corticosteroids have been evaluated to control the excessive immune response seen in cerebral malaria; however, clinical trials have generally shown limited benefits and potential adverse effects, leading to cautious use (Prasad et al., 2011).

Nutritional supplementation has also been proposed as an adjunct measure, particularly in malaria-endemic regions where micronutrient deficiencies are common. Zinc, vitamin A, and folate supplementation have shown varying degrees of efficacy in supporting immune function and recovery during malaria episodes (Shankar et al., 1999). Moreover, blood transfusion remains an important supportive therapy in severe anemia associated with *Plasmodium falciparum* infection, especially among pediatric patients (English et al., 2002).

Emerging research is exploring novel adjunctive options, such as nitric oxide therapy for improving microvascular function, and the use of statins for their immunomodulatory and endothelial-protective effects (Yeo et al., 2007). The integration of such adjunctive measures with effective antimalarial regimens may help address the multifactorial nature of malaria pathology and improve survival rates in high-risk patient populations.



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	Sensitivity	Specificity	Cost	Time to get results
Microscopy	Low	High	Low	Medium
RDTs	Low	Low	Medium	Low
PCR	Low (with low parasitemia)	High	High	High
Aptamers	High	High	Low	Low

Figure 1: Different diagnostic modalities for malaria diagnosis

CONCLUSION

Malaria remains a persistent global health challenge, particularly in tropical and subtropical regions where the disease burden is highest. Despite significant progress in prevention, diagnosis, and treatment, the emergence of drug-resistant *Plasmodium* strains continues to threaten malaria control and elimination efforts (WHO, 2023). Recent advances in antimalarial drug discovery, biomarker research, and adjunctive therapies offer renewed hope for tackling this complex disease.

The integration of novel molecular targets, improved drug formulations, and innovative delivery systems has the potential to enhance treatment efficacy while minimizing adverse effects (Cowman et al., 2016). Biomarkers, particularly those identified through omics-based approaches, can significantly improve early detection, monitor treatment response, and guide clinical decision-making (Wongsrichanalai et al., 2007). Adjunctive therapies, when appropriately implemented alongside effective antimalarial regimens, can further reduce complications and mortality in severe malaria cases (Dondorp et al., 2010).

However, sustained success in malaria control will depend on a multifaceted approach—combining biomedical innovations with strong public health strategies, vector control measures, and community engagement. Continued investment in research, surveillance, and capacity building in endemic regions is crucial for achieving long-term malaria eradication goals (Bhatt et al., 2015).

In conclusion, while substantial challenges remain, the collective progress in drug development, diagnostics, and supportive care offers a promising pathway towards reducing the global malaria burden and ultimately achieving its elimination.

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REFERENCES

1. World Health Organization. (2023). *World malaria report 2023*. WHO.
2. Snow, R. W., Sartorius, B., Kyalo, D., Maina, J., Amratia, P., Mundia, C. W., ... & Noor, A. M. (2017). The prevalence of *Plasmodium falciparum* in sub-Saharan Africa since 1900. *Nature*, 550(7677), 515–518.
3. Bhatt, S., Weiss, D. J., Cameron, E., Bisanzio, D., Mappin, B., Dalrymple, U., ... & Gething, P. W. (2015). The effect of malaria control on *Plasmodium falciparum* in Africa between 2000 and 2015. *Nature*, 526(7572), 207–211.
4. Ashley, E. A., Dhorda, M., Fairhurst, R. M., Amaratunga, C., Lim, P., Suon, S., ... & Dondorp, A. M. (2014). Spread of artemisinin resistance in *Plasmodium falciparum* malaria. *New England Journal of Medicine*, 371(5), 411–423.
5. Noedl, H., Se, Y., Schaecher, K., Smith, B. L., Socheat, D., & Fukuda, M. M. (2008). Evidence of artemisinin-resistant malaria in western Cambodia. *New England Journal of Medicine*, 359(24), 2619–2620.
6. Cowman, A. F., Healer, J., Marapana, D., & Marsh, K. (2016). Malaria: Biology and disease. *Cell*, 167(3), 610–624.
7. Vyas, S., Gupta, S., & Jain, S. (2013). Nanomedicine approaches for the treatment of malaria. *Current Drug Delivery*, 10(2), 153–160.

8. Dhangadamajhi, G., Mohapatra, B. N., & Kar, S. K. (2010). Genetic polymorphism of *Plasmodium falciparum* histidine-rich protein-2 gene in Indian isolates. *Acta Tropica*, 113(3), 217–221.
9. Wongsrichanalai, C., Barcus, M. J., Muth, S., Sutamihardja, A., & Wernsdorfer, W. H. (2007). A review of malaria diagnostic tools: Microscopy and rapid diagnostic test (RDT). *American Journal of Tropical Medicine and Hygiene*, 77(6 Suppl), 119–127.
10. Gamboa, D., Ho, M. F., Bendezu, J., Torres, K., Chiodini, P. L., Barnwell, J. W., ... & Cheng, Q. (2010). A large proportion of *P. falciparum* isolates in the Amazon region of Peru lack *pfhrp2* and *pfhrp3*: Implications for malaria rapid diagnostic tests. *PLoS One*, 5(1), e8091.
11. Mahmood, K., Zia, N., & Hussain, R. (2011). Cytokine levels in malaria and their correlation with severity of disease. *Journal of the Pakistan Medical Association*, 61(6), 590–595.
12. Kamleh, M. A., Hobani, Y., Dow, J., Watson, D. G., & Barrett, M. P. (2008). Metabolomic profiling of malaria-infected red blood cells. *Journal of Proteome Research*, 7(7), 3060–3068.
13. Cheng, X., Irimia, D., Dixon, M., Sekine, K., Demirci, U., Zamir, L., ... & Whitesides, G. M. (2014). A microfluidic device for practical diagnostics of malaria. *Lab on a Chip*, 14(6), 1074–1082.
14. Dondorp, A. M., Fanello, C. I., Hendriksen, I. C., Gomes, E., Seni, A., Chhaganlal, K. D., ... & Day, N. P. (2010). Artesunate versus quinine in the treatment of severe falciparum malaria in African children (AQUAMAT): An open-label, randomised trial. *The Lancet*, 376(9753), 1647–1657.
15. Reyburn, H., Mbatia, R., Drakeley, C., Bruce, J., Carneiro, I., Olomi, R., ... & Greenwood, B. M. (2004). Association of transmission intensity and age with clinical manifestations and case fatality of severe *Plasmodium falciparum* malaria. *JAMA*, 291(20), 2542–2550.
16. Prasad, K., Garner, P., & Steroids for treating cerebral malaria. (2011). Steroids for treating cerebral malaria. *Cochrane Database of Systematic Reviews*, (1), CD002243.
17. Shankar, A. H., Genton, B., Semba, R. D., Baisor, M., Paino, J., Tamja, S., ... & Alpers, M. P. (1999). Effect of vitamin A supplementation on morbidity due to *Plasmodium falciparum* in young children in Papua New Guinea: A randomised trial. *The Lancet*, 354(9174), 203–209.
18. English, M., Ahmed, M., Ngando, C., Berkley, J., & Ross, A. (2002). Blood transfusion for severe anaemia in African children: Indications, safety and out-come. *The Lancet*, 359(9305), 227–228.
19. Yeo, T. W., Lampah, D. A., Gitawati, R., Tjitra, E., Kenangalem, E., Piera, K., ... & Anstey, N. M. (2007). Impaired nitric oxide bioavailability and L-arginine–reversible endothelial dysfunction in adults with falciparum malaria. *The Journal of Experimental Medicine*, 204(11), 2693–2704.
20. World Health Organization. (2023). *World malaria report 2023*. WHO.
21. Cowman, A. F., Healer, J., Marapana, D., & Marsh, K. (2016). Malaria: Biology and disease. *Cell*, 167(3), 610–624.
22. Wongsrichanalai, C., Barcus, M. J., Muth, S., Sutamihardja, A., & Wernsdorfer, W. H. (2007). A review of malaria diagnostic tools: Microscopy and rapid diagnostic test (RDT). *American Journal of Tropical Medicine and Hygiene*, 77(6 Suppl), 119–127.
23. Dondorp, A. M., Fanello, C. I., Hendriksen, I. C., Gomes, E., Seni, A., Chhaganlal, K. D., ... & Day, N. P. (2010). Artesunate versus quinine in the treatment of severe falciparum malaria in African children (AQUAMAT). *The Lancet*, 376(9753), 1647–1657.
24. Bhatt, S., Weiss, D. J., Cameron, E., Bisanzio, D., Mappin, B., Dalrymple, U., ... & Gething, P. W. (2015). The effect of malaria control on *Plasmodium falciparum* in Africa between 2000 and 2015. *Nature*, 526(7572), 207–211.