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Nigeria at 62: Quagmire of malaria and the urgent need for deliberate and concerted control strategy

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Background: Sub-Saharan Africa (SSA) has disproportionately contributed the majority (95%) of all malaria cases and deaths for more than a decade (2010-2021) and Nigeria contributes the highest in global malaria cases and deaths in the last decade.

Main body: Despite several malaria control initiatives, why is Nigeria still the most endemic malaria country? Published reports have underlined possible reasons for the sustenance of malaria transmission. Malaria transmission pattern in the country is largely and remarkably heterogeneous, hence control measures must take this uniqueness into consideration when designing intervention strategies. Nigeria became 62 years post-independence on the 1st of October, 2022, therefore making positive impacts on all aspects of the country, especially in the health sector becomes imperative more than ever before. To achieve a pre-elimination malaria status, we propose the implementation of focused and calculated research strategies. Such strategies would be consciously geared towards understanding vectorial capacity, susceptibility to approved insecticides, identifying malaria hotspots, and deciphering the genetic structure and architecture of *P. falciparum* within and between groups and regions. This will provide insight into delineating the inter/intra-regional migration of parasite populations, amongst others.

Conclusion: With regard to malaria elimination, Nigeria still has a long way to go. There is a need for dedicated prioritization of research efforts that would provide a basic understanding of the *Plasmodium* parasite in circulation. Such information will support the implementation of policies that will drive down malaria transmission in Nigeria.

KEYWORDS
Nigeria, malaria, focused-research, heterogeneous, elimination.

Introduction

Malaria in Nigeria is predominantly caused by *Plasmodium falciparum* and the country experiences varied endemicity due to the different ecological zones across different states, supporting uneven parasite transmission. Moreover, of the estimated 241 million cases and 627,000 deaths reported in 2021, sub-Saharan Africa (SSA) contributes 95%, while Nigeria is responsible for 24% of the global cases and mortality within the same period (1). Nigeria, a country that is 62 years post-independence on the 1st of October 2022, continues to be the most overburdened in terms of morbidity and mortality. Since the last decade, Nigeria and the Democratic Republic of Congo have topped the number of malaria cases and deaths. However, Nigeria has taken the lead in contributing approximately a quarter (25%) of the total cases and deaths, except in 2017 (2), 2018 (3), 2019 (4), and 2020 (5), where it contributed 24%, 19%, 24%, and 23% respectively.

Main text

The Federal Ministry of Health, Nigeria through the National Malaria Elimination Program has instituted various control measures (6) amidst this gloomy report. The different control strategies being implemented include indoor residual spraying of wall surfaces with dichlorodiphenyltrichloroethane (DDT) and pyrethroids, distribution of long-lasting insecticide-treated nets, and larviciding in different parts of the country at different rates (6, 7). On the other hand, seasonal malaria chemoprevention, intermittent preventive treatment (in pregnant women and infants) with sulphadoxine-pyrimethamine and the use of artemisinin-based combination therapy (ACT) is being used to treat, and prevent malaria infections in susceptible individuals (8). Despite these control initiatives, however, Nigeria is still the most burdened malaria country. Published reports have underlined possible reasons discussed below responsible for the sustenance of malaria transmission.

Vector control interventions are sparingly contextualized to the different ecological zones of the country. In Nigeria, there are six ecotypes: Sahel, Sudan, Guinea savannah, Rainforest, mangrove forest, and freshwater. Peripherally, these ecological zones fall on the northern (Sahel, Sudan, and Guinea Savannah), and southern belts (rainforest, mangrove forest, and freshwater (9). Precipitation, which is a major driver of vector breeding and abundance varies significantly across these zones. For example, the Sahelo-Sudan-Guinea savannah has low precipitation (<2000 mm) (9, 10), while precipitation in the rainforest, mangrove forest and freshwater can be as high as 4000 mm per annum. An in-depth and adequate understanding of vector dynamics across these various zones would positively impact malaria control efforts in Nigeria.

In addition, several anopheline vectors abound in Nigeria from *An. gambiae s.l*, *An funestus*, *An. arabiensis* (11). However, some of these vectors can sometimes be geographically localized: for instance, *An. moucheti*, and *An. melas* has been found to be present and transmit malaria in the rainforest and mangrove forest ecotypes predominantly covering southern Nigeria, but absent in the guinea savannah (northwestern Nigeria) zone (10, 12).

Most studies have principally focused on the composition of vectors, sporozoites rate, entomological inoculation rate, biting behaviors, or insecticide resistance genes (11, 13, 14). The differences in the ecotypes present an opportunity to design vector-tailored control initiative that is peculiar to each zone: for instance, in the rainforest, mangrove forest, and freshwater zones where precipitation can be up to 4000 mm per annum, vector control initiatives such as larviciding would have to be implemented just before the rainy season (January –March in rainforest and mangrove forest; December –May in freshwater ecological zones) and not during the period of heavy rains when larvicides can be easily washed off. In addition, the behavior of ecotype-specific vectors and how they manifest when there is a change of season will be impactful in implementation of control strategies. Though a long-term goal, a deep and focused study to understand how each vector species contributes to, or evaluation of vector microbiome that can be employed to inhibit malaria transmission will provide valuable insights into vector capacity.

Malaria transmission pattern in Nigeria is largely and remarkably heterogeneous, hence control measures must take this uniqueness into consideration while designing intervention strategies. Healthcare accessibility differs between rural and urban areas, where it has been reported that individuals are more likely to embrace control measures, especially the use of insecticide-treated nets in urban as opposed to rural areas (15). Moreover, it has been reported that there is high probability of indiscriminate use of proscribed antimalarials (16–18) that could potentially contribute to drug-resistant parasites in circulation (19, 20). In addition, living in housing patterns that are conducive to mosquito breeding would strongly ensure continuous malaria transmission. Adding to the litany of factors ensuring the high and continuous transmission of malaria is the obvious change in climatic conditions. Different epidemiological and modeling studies (9, 21–23) have attributed a correlation between increased precipitation and temperature with vector abundance and hence malaria transmission. Some of the states in Nigeria sit along coastal lines where the excessive flow of water from dams in neighboring countries leads to flood; a situation that is almost an annual occurrence.

What course of action must then be taken to alleviate Nigeria from this perpetual malaria burden, and achieve a pre-elimination status? First, an increased political commitment at all levels of government, within and between various parastatals, is urgent and imperative. This will ensure that Nigeria, a signatory to the United Nations' sustainable development goal, which seeks to ensure healthy lives and promote well-being for all ages among other things, meets the World Health Organization 2030 Malaria Elimination Plan, or at least is on track to attaining a pre-elimination status. Therefore, adequate planning to prevent the frequent flooding that occurs in some states must be instituted. Drainages along those coastal areas should be dredged to ensure the free flow of water. Additionally, structured and strategic research plans need to be established. Such will include continuous monitoring of vectorial capacity, and strengthening of ongoing vector susceptibility tests to insecticides in use (13), identifying hotspots of malaria transmission, understanding the genetic structure and architecture of *P. falciparum* within and between Nigerian groups, and geographical regions, delineating the inter/intra-regional migration of parasite populations. Furthermore, it will also be geared towards identifying the extent, dynamics, and heterogeneous nature of non-falciparum malaria transmission within the country. It is equally crucial for national policymakers to quickly align and identify with recent policies evidenced to reduce malaria morbidity within the country. The post-discharge malaria chemoprevention (PDMC) initiative is recommended to reduce hospital readmission and death in children who have been treated for severe malarial anemia (SMA). Children admitted for SMA do not regain full hematological function until 2-3 months. Hence, treatment of these children with approved ACTs 3- 6 months post-discharge has been found to be very effective in Kenya, Uganda (24), and Malawi (25). Data from modeling studies have also shown that PDMC can reduce malaria readmission by 37,000 annually in Africa (26). If implemented in Nigeria, PDMC may provide considerable protection against malaria and anemia in young children. As immunization is one of the most effective disease control strategies, it is crucial that the government through the Ministry of Health make prudent plans for the acquisition and deployment of the newly approved RTS S/ASO1 vaccine (27) to the most vulnerable group - children. The provision of an added 30% protection against malaria episodes will undoubtedly reduce the number of country-wide cases and ultimately mortality. Moreover, the approval of the promising R21/Matrix M malaria vaccine will provide an additional tool for prophylaxis. Due to reports of *P. falciparum* histidine-rich protein II gene deletion in some parts of the country (28), we recommend that a non-hrp2 pan-specific malaria rapid diagnostic test (mRDT) be deployed. This will provide the added benefit of being able to detect non-falciparum species that may be present even though their contribution to malaria in Nigeria is insignificant.

Conclusion

As Nigeria remains the highest global contributor of malaria cases and mortality, attaining the global malaria elimination 2030 target will require, on the one hand, a combination of various effective control strategies that will target the different factors sustaining malaria transmission in the various ecological zones; and on the other hand, a focused, calculated, and conscious research efforts to gain a better understanding of the parasite and their behavior to different control measures.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

MO conceptualized and wrote the first draft. KO, OA and BT provided critical review. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

1. WHO. *World malaria report* (2021). Available at: https://www.who.int/publications/i/item/9789240040496.

2. WHO. *World malaria report 2017*. (2017). World Health Organisation.

3. WHO. *World malaria report* (2018). Available at: https://www.who.int/publications/i/item/9789241565653.

4. WHO. *World malaria report 2019* (2019). Available at: https://www.who.int/publications/i/item/9789241565721.

5. WHO. *World malaria report*. (2020). World Health Organisation. doi: 10.1002/(SICI)1096-8628(19971128)73:1<1::AID-AJMG1>3.0.CO;2-Y.

6. FMoH. *National malaria indicator survey*. (Nigeria: Federal Ministry of Health) (2015). doi: 10.1017/CBO9781107415324.004.

7. Dimas HJ, Sambo NM, Ibrahim MS, Ajayi IOO, Nguku PM, Ajumobi OO, et al. Coverage of indoor residual spraying for malaria control and factors associated with its acceptability in nasarawa state, north-central Nigeria. *Pan Afr Med J* (2019) 33:84–91. doi: 10.11604/pamj.2019.33.84.13212

8. FMoH. *National guidelines for diagnosis and treatment of malaria, 3rd ed*. (Nigeria: Federal Ministry of Health) (2015).

9. Ayanlade A, Nwayor IJ, Sergi C, Ayanlade OS, Di Carlo P, Jeje OD, et al. Early warning climate indices for malaria and meningitis in tropical ecological zones. *Sci Rep* (2020) 10:14303. doi: 10.1038/s41598-020-71094-8

10. Okwa OO, Akinmolayan FI, Carter V, Hurd H. Transmission dynamics of malaria in four selected ecological zones of nigeriain the rainy season. *Ann Afr Med* (2009) 8(1):1–9. doi: 10.4103/1596-3519.55756

11. Awolola TS, Ibrahim K, Okorie T, Koekemoer LL, Hunt RH, Coetzee M. Species composition and biting activities of anthropophilic anopheles mosquitoes and their role in malaria transmission in a holo-endemic area of southwestern Nigeria. *Afr Entomol* (2003) 11(2):227–32. Available at: https://hdl.handle.net/10520/EJC32558

12. Awolola TS, Okwa O, Hunt RH, Ogunrinade AF, Coetzee M. Dynamics of the malaria-vector populations in coastal Lagos, south-western Nigeria. *Ann Trop Med Parasitol* (2002) 96(1):75–82. doi: 10.1179/000349802125000538

13. Awolola TS, Adeogun A, Olakiigbe AK, Oyeniyi T, Olukosi YA, Okoh H, et al. Pyrethroids resistance intensity and resistance mechanisms in anopheles gambiae from malaria vector surveillance sites in Nigeria. *PloS One* (2018) 13(12):e0205230. doi: 10.1371/journal.pone.0205230

14. Oyewole IO, Awolola TS. Impact of urbanisation on bionomics and distribution of malaria vectors in Lagos, southwestern Nigeria. *J Vector Borne Dis* (2006) 43(4):173–8.

15. Duodu PA, Dzomeku VM, Emerole CO, Agbadi P, Arthur-Holmes F, Nutor JJ. Rural-urban dimensions of the perception of malaria severity and practice of malaria preventive measures: Insight from the 2018 Nigeria demographic and health survey. *J Biosoc Sci* (2021) 1–18. doi: 10.1017/S0021932021000420

16. Gbotosho GO, Happi CT, Ganiyu A, Ogundahunsi OA, Sowunmi A, Oduola AM. Potential contribution of prescription practices to the emergence and spread of chloroquine resistance in south-west Nigeria: Caution in the use of artemisinin combination therapy. *Malaria J* (2009) 8(1):1–8. doi: 10.1186/1475-2875-8-313

17. Ezenduka CC, Ogbonna BO, Kwunife O, Okonta M, Esimone CO. Antimalarial drugs use pattern in retail outlets in enugu urban south East nigeria; implication for malaria treatment policy. *Malaria J* (2014) 13:243. doi: 10.1016/j.jval.2014.03.1638

18. O'Boyle S, Bruxvoort KJ, Ansah EK, Burchett HED, Chandler CIR, Clarke SE, et al. Patients with positive malaria tests not given artemisinin-based combination therapies: A research synthesis describing under-prescription of antimalarial medicines in Africa. *BMC Med* (2020) 18:17. doi: 10.1186/s12916-019-1483-6

19. Oboh MA, Singh US, Antony HA, Ndiaye D, Badiane AS, Ali NA, et al. Molecular epidemiology and evolution of drug-resistant genes in the malaria parasite plasmodium falciparum in southwestern Nigeria. *Infect Genet Evol* (2018) 66:222–8. doi: 10.1016/j.meegid.2018.10.007

20. Kayode AT, Akano K, Ajogbasile FV, Uwanibe JN, Oluniyi PE, Bankole BE, et al. Polymorphisms in plasmodium falciparum chloroquine resistance transporter (Pfcrt) and multidrug-resistant gene 1 (Pfmdr-1) in Nigerian children 10 years post-adoption of artemisinin-based combination treatments. *Int J Parasitol* (2021) 51(4):301–10. doi: 10.1016/j.ijpara.2020.10.001

21. Caminade C, Kovats S, Rocklov J, Tompkins AM, Morse AP, Colón-González FJ, et al. Impact of climate change on global malaria distribution. *Proc Natl Acad Sci United States America* (2014) 111(9):3286–91. doi: 10.1073/pnas.1302089111

22. Upadhyayula SM, Mutheneni SR, Chenna S, Parasaram V, Kadiri MR. Climate drivers on malaria transmission in arunachal pradesh, India. *PloS One* (2015) 10(3):e0119514. doi: 10.1371/journal.pone.0119514

23. Ngarakana-Gwasira ET, Bhunu CP, Masocha M, Mashonjowa E. Assessing the role of climate change in malaria transmission in Africa. *Malaria Res Treat* (2016) 2016:1–7. doi: 10.1155/2016/7104291

24. Kwambai TK, Dhabangi A, Idro R, Opoka R, Watson V, Kariuki S, et al. Malaria chemoprevention in the postdischarge management of severe anemia. *New Engl J Med* (2020) 383(23):2242–54. doi: 10.1056/nejmoa2002820

25. Phiri K, Esan M, Van Hensbroek MB, Khairallah C, Faragher B, Ter Kuile FO. Intermittent preventive therapy for malaria with monthly artemether-lumefantrine for the post-discharge management of severe anaemia in children aged 4-59 months in southern Malawi: A multicentre, randomised, placebo-controlled trial. *Lancet Infect Dis* (2012) 12(3):191–200. doi: 10.1016/S1473-3099(11)70320-6

26. Okell LC, Kwambai TK, Dhabangi A, Khairallah C, Nkosi-Gondwe T, Opoka R, et al. Projected health impact of post-discharge malaria chemoprevention among children under the age of five years with severe malarial anaemia in Africa: a modelling analysis. *medRxiv* (2022), 1–28. doi: 10.1101/2022.01.26.22269679v1

27. The Lancet. Malaria vaccine approval: a step change for global health. *Lancet* (2021) 398(10309):1381. doi: 10.1016/S0140-6736(21)02235-2

28. Funwei R, Nderu D, Nguetse CN, Thomas BN, Falade CO, Velavan TP, et al. Molecular surveillance of pfhrp2 and pfhrp3 genes deletion in plasmodium falciparum isolates and the implications for rapid diagnostic tests in Nigeria. *Acta Trop Elsevier* (2019) 196:121–5. doi: 10.1016/j.actatropica.2019.05.016