

Malaria in Urban Kisangani: A Study of the Socio-Environmental Factors of Transmission.

Research Protocol

Héritier Guld Amosi Kikwata^{1, ID, &}, Starmans Bofoe Lokango², Venance Feruzi Kikuni³, Kakule Lwanga⁴, Dieu-Merci Kombozi Yaya^{4, 5}, Théophile Yanyongo Twangaka⁴, Alliance Tagoto Tepungipame⁴, Eugene Basandja Longembe⁴, John Panda Lukongo Kitronza^{4, 6}.

¹*Department of Public Health, Faculty of Medicine and Pharmacy, University of Kisangani, Kisangani Free University, Democratic Republic of Congo*

²*Faculty of Law, University of Kisangani, Democratic Republic of Congo*

³*Public Health, Higher Institute of Medical Techniques of Kisangani*

⁴*Department of Public Health, Faculty of Medicine and Pharmacy, University of Kisangani, Democratic Republic of Congo*

⁵*Department of Public Health, Higher Institute of Medical Techniques of Yangambi, Faculty of Medicine and Pharmacy, University of Kisangani, Democratic Republic of Congo*

⁶*Department of Public Health, Faculty of Medicine and Pharmacy, University of Kisangani, Democratic Republic of Congo, University of Liège, Belgium*

[&]*Auteur correspondant : Héritier Guld Amosi Kikwata, Université de Kisangani (E-mail : kktguldamosi@gmail.com ; ID ORCID: [0009-0001-1401-0117](https://orcid.org/0009-0001-1401-0117), Téléphone/WhatsApp : (+243) 81.16.43.727, 85.23.67.131).*

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Abstract

Introduction

Malaria, despite progress made, remains a major public health issue in sub-Saharan Africa and the Democratic Republic of Congo, where it represents a considerable challenge, with intense transmission. Several studies have highlighted the importance of environmental and socio-economic factors in malaria transmission, but few in Kisangani.

Purpose

This study aims to identify the socio-economic and environmental factors that influence malaria transmission in urban Kisangani. This identification will allow for the proposal of adapted prevention strategies.

Methods

This will be an analytical cross-sectional study that will take place from December 1, 2023, to May 15, 2024. The statistical units within households will consist of household heads, pregnant women, and children aged 0 to 5 years. Using Schwartz's formula ($z^2pq/d2$) with an anticipated non-response rate of 5%, a sample of 403 households will be selected randomly and systematically. These will be guided interviews using a structured survey questionnaire on KoboCollect. Surveyors will administer these questionnaires and collect blood samples to assess malaria parasitemia. Data will be analyzed with STATA 13 software. Descriptive and inferential statistics will be used to describe the characteristics of the respondents and identify the factors associated with malaria transmission in urban areas.

Expected Results

The results will be presented in tables and graphs to describe the characteristics of the individuals, and a bivariate analysis will identify the associated factors.

Conclusion

This study will contribute to improving the understanding of malaria transmission in urban Kisangani and will provide essential information for more effective and locally adapted prevention strategies.

Keywords: *Malaria, Transmission, Factors, Public Health, Kisangani, Democratic Republic of the Congo.*

Introduction

Malaria, although known since the 19th century and having been the subject of many advances, remains a considerable threat to global public health, particularly in sub-Saharan Africa (SSA) (BECHIR BEN, 2018, WHO, 2022). The progress made between 2000 and 2015 has certainly raised hopes of eradication (WHO, 2021), but this disease continues to weigh heavily on millions of individuals.

Malaria, despite progress made, remains a major public health issue and a hindrance to sustainable development, affecting hundreds of millions of people and causing hundreds of thousands of deaths each year (WHO, 2022, WHO, 2021, Rasmane et al., 2023, Gibson, 2024). Although it is preventable and curable (Kaoudja, 2022), this disease, recognized as an environmental problem and intimately linked to living conditions (Kouamé Hyacinthe, 2020), continues to rage, and its link with climate change is increasingly evident (Hilaire, 2017).

Several studies highlight the importance of environmental and socio-economic factors in malaria transmission, such as the rainfall regime in Cambodia which influences the resurgence of the disease (Tomasi & Vanny, 2015), or the degradation of environmental conditions and rapid urbanization which have contributed to the increase in cases in Madras, India, despite anti-malaria programs (Hyma, B., Ramesh, A., & Chakrapani, KP., 1983). In addition, population movements can connect areas with different levels of transmission, thus maintaining the disease, as observed along the border between Thailand and Myanmar (Chaumeau, 2017).

Malaria remains a major problem in Africa, concentrating the majority of cases and deaths worldwide, with increased vulnerability among pregnant women and children under 5 years of age (WHO, 2022). Although the fight against malaria has made progress, the evolution of the disease in

African cities is complex, with urban populations becoming infected not only during travel to rural areas, but also in the city, particularly in the peripheral neighborhoods (Cussac, 2021). To strengthen the fight against malaria, it is crucial that African countries address the weaknesses of their health systems, improve the quality and use of surveillance data, strengthen technical and leadership skills, and reduce their dependence on products, while expanding multisectoral initiatives such as improving housing and sanitation (Okumu, F., et al., 2022).

In Senegal, despite a decrease in malaria morbidity, the epidemiology remains heterogeneous, with persistent transmission in the southeast of the country and many cases among older children and adolescents. Environmental factors and non-use of preventive measures are the main determinants of transmission among adolescents living in these areas of persistent transmission (Tairou et al., 2022). In Kenya, factors such as proximity to water, vegetation, population density and rainfall have a variable impact on the incidence of malaria. The El-Nino-Southern Oscillation (ENSO) event of 2015 notably contributed to an increase in cases in the southern region of Lake Victoria (Gopal, S., Ma, Y., n.d.). A study conducted in Burkina Faso revealed that sleeping spaces with a metal roof had a 45% lower rate of *Anopheles gambiae* sl compared to those with thatched roofs. Improving housing construction, particularly by installing metal roofs, could reduce the burden of malaria in endemic areas of Africa (Ouédraogo et al., 2021). In Cameroon, a 2021 study highlights that a combination of high *Plasmodium falciparum* infection in mosquitoes, insufficient coverage and loss of effectiveness of insecticide-treated nets due to their physical degradation, as well as high resistance to insecticides, explains the persistence of high malaria transmission in rural forest areas (Ndeffo-Mbetse et al.,

2020). Finally, in Rwanda in 2020, a study established a link between the increase in malaria prevalence and lower incomes, non-compliance with the use of mosquito nets and living at altitudes below 1,700 m. Targeted interventions among low-income populations and low-altitude areas are needed to complement current malaria control strategies, emphasizing the use of insecticide-treated nets (Rudasingwa & Cho, 2020).

Malaria is undeniably linked to the environment. However, in the search for solutions to combat this disease, the emphasis is often placed on health interventions, to the detriment of social and environmental approaches. Consequently, the latter are insufficiently taken into account in malaria control strategies (Birane et al., 2016).

In the Democratic Republic of Congo (DRC), malaria represents a major challenge for public health, ranking as the leading cause of illness and death, with the country sharing with Nigeria nearly 40% of the global burden of this disease (WHO, 2022). Despite a slightly smaller population than Nigeria, the DRC records a considerably higher number of annual cases, with an endemic affecting 97% of the population living in areas of stable transmission (WHO, 2022).

In 2020, the DRC accounted for 12% of malaria cases and 13.2% of deaths from the disease worldwide, with the country also accounting for 53.1% of malaria cases in Central Africa (WHO, 2022).

An increase in incidence and hospital mortality was observed in 2022. Several factors could explain this increase in incidence, including a significant increase in the number of health facilities reporting confirmed and suspected cases of malaria, a progressive improvement in data

completeness reaching 99% in 2022 with 100% for basic and secondary services, and the addition of 1,702 additional community care sites in 2022 (WHO, 2022).

In Kinshasa, a 2022 study highlighted the crucial role of socio-environmental factors in the resurgence of malaria, including the lack of community involvement in sanitation, the abundance of larval breeding sites, environmental conditions and climate (Atungale, Atungale, et al., 2022)a, (Atungale, Musibono, et al., 2022). In this context of climate variability, these factors are all the more important to consider as they can exacerbate the development of malaria vectors, as is the case in Kisangani where the equatorial forest and climate favor intense transmission (Labama Otuli et al., 2021).

In Kisangani, research exploring the combined influence of socio-environmental factors on malaria transmission remains scarce.

The objective of this study will be to identify the socio-economic and environmental factors that influence malaria transmission in urban Kisangani. This will allow for the proposal of adapted prevention strategies.

Conceptual framework

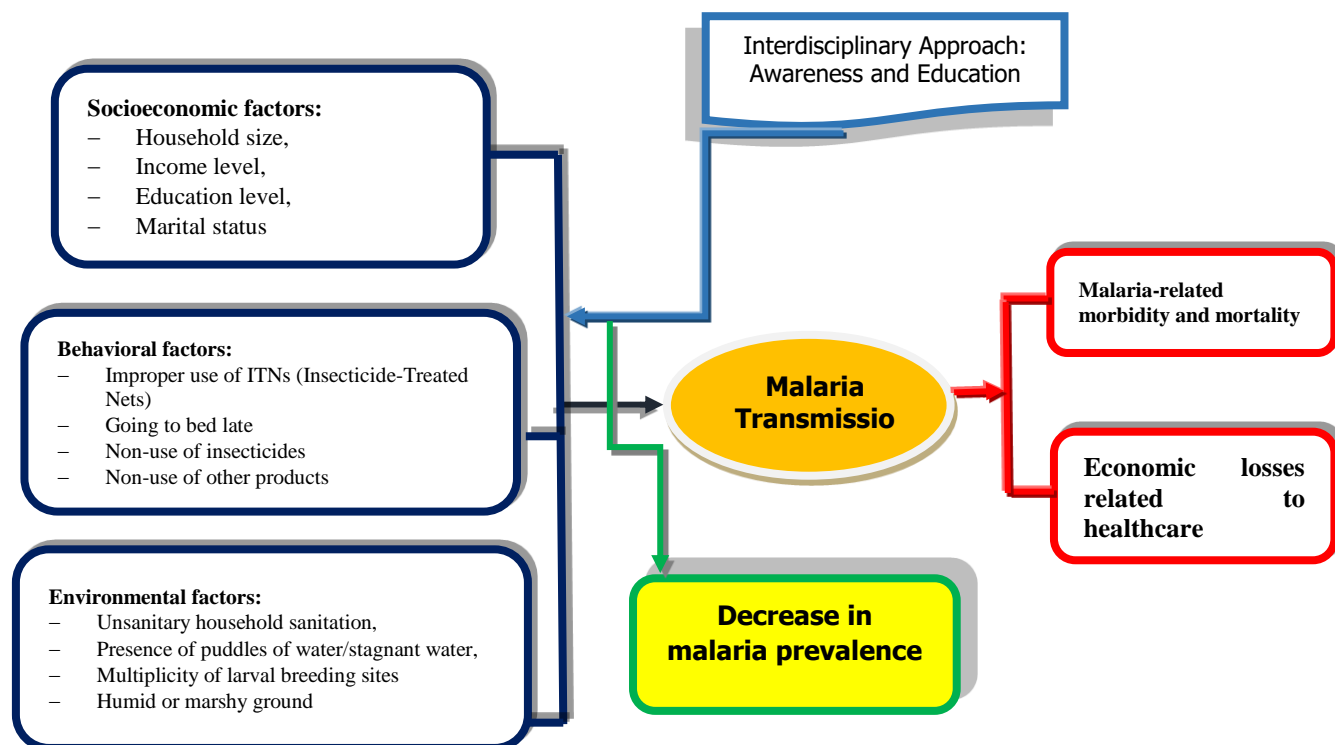


Figure 1: Conceptual framework

This conceptual framework highlights the complexity of malaria transmission, which is influenced by interdependent socio-economic, environmental, and behavioral factors. It emphasizes the essential role of community awareness and education as a cross-cutting strategy to address these different factors and reduce malaria-related morbidity and mortality.

Méthodes

Study framework

Kisangani, the capital of the Tshopo Province and a major urban center in the northern part of the DRC, will be the location of our research.

General overview of the city of Kisangani

The city of Kisangani, located in the Democratic Republic of Congo, is characterized by an equatorial climate with high temperatures and abundant rainfall (DPINS TSHOPO, 2016). Epidemiologically, the city presents an equatorial facies, with stable and intense malaria transmission, reaching at least 1,000 infective mosquito bites per year per person (Labama Otuli et al., 2021). Socio-

economically, Kisangani is characterized by a generally low level, with approximately 50% of the population living in poverty (Labama Otuli et al., 2021).

The city of Kisangani is divided into 5 health zones, but due to the current security situation in the commune of Lubunga, only four health zones will be included in this study: Kabondo, Tshopo, Mangobo and Makiso-Kisangani.

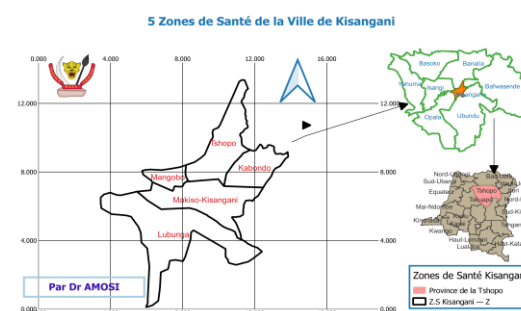


Figure 2: Map of the 5 Health Zones of the city of Kisangani

Study population

This study will be conducted among household heads in the city of Kisangani, distributed across the health areas (HA). General information relating to households will be collected from these household heads. The study will also include pregnant women and children under 5 years of age living in these households, from whom blood samples will be taken and analyzed at the large laboratory of the Kabondo General Reference Hospital (GRH).

Study period and type

Over a period of four and a half months, from December 1, 2023, to May 15, 2024, we will conduct an analytical cross-sectional study.

Sampling

To compensate for an anticipated non-response rate of 5%, we will adjust our initial sample of 384 households to 403, using Schwartz's formula ($n = (z^2pq)/d^2$), and we will randomly select five health areas per urban health zone, then two avenues per health area, before applying systematic sampling to ensure geographical representativeness and a homogeneous distribution of households, and the study participants will be adults residing in or around Kisangani for at least six months, having a child under five years of age and/or a pregnant woman in the household, and giving their informed verbal consent.

Inclusion criteria

To participate in the study, individuals must reside in Kisangani for at least six months, be 18 years of age or older, belong to a household selected according to the methodology described, and have at least one child aged 0 to 5 years or a pregnant woman in their home; a household head must also be present to give their informed verbal consent, and parental consent will be

required for minor children. Pregnant women who are ill and individuals meeting the inclusion criteria but visiting the selected household will be excluded.

Data collection

The research team will use KoboCollect to collect data on malaria parasitemia, socio-economic factors, environmental practices and prevention behaviors, training investigators in the use of this platform and geolocating households for spatial analysis of data, which will be regularly synchronized with a central server to ensure their backup and facilitate their analysis. Teams of three composed of a laboratory technician, a community health worker and an investigator will be assigned to each health area to foster collaboration and adapt the methodology to local specificities, with regular coordination meetings to maintain positive group dynamics. After obtaining informed consent from participants, a structured questionnaire with closed-ended questions, translated into Swahili and Lingala, will be administered by trained investigators, and a pre-test will be conducted with 50 subjects to ensure understanding of the questions and comfort of participants.

Blood sample collection

In order to assess malaria parasitemia, blood samples will be taken from all children under 5 years of age and all pregnant women present in the selected households. In order to limit the total number of samples and reduce potential stress for participants, the number of children under 5 years of age and pregnant women per household will be limited to 5 and 2 respectively, for households with a larger number in these categories. All samples will be taken under strict hygienic conditions by qualified personnel and the samples will be transported and stored in accordance with current protocols.

Operational definitions

To assess the household income level, we will assign scores to the possession of certain goods and access to certain services, such as drinking water, the type of toilet, the energy source, and the possession of durable goods. The total score will be used to categorize households into three living standards: high, medium, and low.

Regarding knowledge about malaria, we will evaluate the participants' ability to cite the modes of transmission, means of prevention, and consequences of the disease. They will then be classified into three levels of knowledge: high, medium, and low, based on the number of correct answers in each category.

Variables of Interest

Our study will aim to identify the factors associated with the presence of malaria in children under 5 years of age and pregnant women, by examining variables such as socio-economic characteristics, prevention-related behaviors, and environmental factors. More specifically, we will analyze the presence or absence of malaria (detected by RDT and/or GE) in relation to age, sex, education level, marital status, occupation, income, household composition, malaria awareness, knowledge of the consequences and means of prevention, use of ITNs, sanitation, the presence of larval breeding sites, the wastewater and waste disposal system, as well as soil characteristics.

Data Analysis

The raw data, collected via KoboCollect, will be cleaned and structured in an Excel file, then statistically analyzed with STATA version 13. Descriptive statistics (mean, standard deviation, median, interquartile range, proportions) will describe household characteristics, while statistical inferences (Pearson's chi-squared test, crude odds ratio) will assess the associations between

variables, with a significance level of 5%. The data from this study will be synthesized and visualized in the form of tables and graphs.

Analysis of Blood Samples

The blood samples taken from pregnant women and children under 5 years of age participating in our study will be transported to the main laboratory of the Kabondo General Reference Hospital (HGR), where microscopic analyses will be performed by a biologist to detect the presence of malaria parasites. Malaria Rapid Diagnostic Tests (RDTs) will be performed on-site using specific equipment and a precise operating procedure, including preparation, blood collection, reading and interpretation of results, as well as waste management. The thick blood smear will also follow a standardized procedure, from blood collection to microscopic examination, through fixation and staining, with standard precautions and rigorous quality control.

Conclusion

This study aims to comprehensively examine the socio-economic, behavioral, and environmental factors of malaria transmission in the urban environment of Kisangani, Democratic Republic of Congo. By using an approach that combines parasitological data with socio-economic, behavioral, and environmental information, the research seeks to provide a holistic understanding of the factors influencing malaria prevalence in this specific urban context. The results of this study will have significant implications for public health interventions, policy formulation, and community initiatives aimed at reducing the burden of malaria in Kisangani and similar urban areas.

Based on the study plan and expected results, to improve malaria control, it is crucial to implement targeted interventions based on the identified risk factors, such as

improving infrastructure, environmental management, prevention education, and socio-economic empowerment. In addition, it is essential to translate these results into effective public policies, strengthen intersectoral collaboration, and encourage future research and community engagement for sustainable solutions.

Ethical considerations

Administrative authorizations necessary for the realization of this study will be obtained from the provincial Ministry of Health and the University of Kisangani. Participation in the study will be voluntary, with verbal consent from all household heads and verbal assent collected from parents for the participation of their children. The interviews will be conducted in the participants' native language, and all data will be anonymized before being analyzed.

Conflicts of interest

The authors declare no conflict of interest.

Contributions of the Authors

All authors have made a significant scientific contribution to this article and have approved its final version, thus attesting to their agreement on the content.

ORCID IDs:

Héritier Guld Amosi Kikwata^{3,1} : [0009-0001-1401-0117](https://orcid.org/0009-0001-1401-0117)

Kakule Lwanga³ : [0009-0002-8634-1780](https://orcid.org/0009-0002-8634-1780)

Dieumerici Kombozi Yaya³⁻⁴ : [0009-0000-0706-0047](https://orcid.org/0009-0000-0706-0047)

Alliance Tagoto Tepungipame³ : [0000-0003-1012-6769](https://orcid.org/0000-0003-1012-6769)

Eugene Basandja Longembe³ : [0000-0002-1383-6742](https://orcid.org/0000-0002-1383-6742)

Emmanuel Tebandite Kasai⁵ : [0000-0003-1274-2127](https://orcid.org/0000-0003-1274-2127)

John Panda Lukongo Kitronza³⁻⁶ : [0000-0001-7840-9082](https://orcid.org/0000-0001-7840-9082)

References

- Atungale, A. M., Atungale, S. C., Atungale, E. A.-N., Munduku, O. M., Musibono, D. A., Tshibangu, J. wa Ka., Metelo, E. M., Lola, A. L., & Ngalafele, E. O.** (2022). Factors related to the behaviors of inhabitants of the Ngaba health zone associated with the resurgence of malaria cases. *International Journal of Social Sciences and Scientific Studies*, 2(3), Article 3.
- Atungale, A. M., Musibono, D., Mansiangi, P., Metelo, E., Atungale, S. C., Tshibangu, J. wa K., & Ngoyi, Z. B.** (2022). Characteristics of larval breeding sites associated with the proliferation of malaria vectors in the Ngaba-Kinshasa Health Zone. *International Journal of Social Sciences and Scientific Studies*, 2(2), Article 2.
- BECHIR BEN, C.** (2018). Social vulnerability of households related to malaria in the city of Yaoundé: A spatial approach -. Memoire Online. <https://www.memoireonline.com/07/21/12019/Vulnerabilite-sociale-des-menages-liee-au-paludisme-dans-la-ville-de-Yaounde-une-approche-spati.html>
- Birane, C., Niang, D. A., Louis, N. J., André, D. J., Christopher, B., Quensière, J., Alioune, K., & Ousmane, F.** (2016). Environmental risk factors for the persistence of malaria in the suburbs of Dakar (Guédiawaye-Pikine). *International Journal of*

- Innovation and Applied Studies*, 15(2), 275.
- Chaumeau**, V. (2017). Entomological determinants of malaria transmission in the cross-border area between Thailand and Myanmar in a context of Plasmodium falciparum elimination [Phdthesis, University of Montpellier]. <https://theses.hal.science/tel-01684277>
- Cussac**, M. (2021). A study on the transmission of urban malaria and culicid nuisance: Impacts of environmental and socio-demographic factors in the city of Ouagadougou (Burkina Faso).
- DPINS TSHOPO**, R. T. (2016). Tshopo Provincial Division of the National Institute of Statistics.
- Gibson**, L. (July 12, 2024). What would a malaria-free future look like. Target Malaria. <https://targetmalaria.org/fr/latest/blog/what-would-a-malaria-free-future-look-like/>
- Gopal**, S., Ma, Y., Xin, C., Pitts, J., & Were, L. (2019). Characterizing the spatial determinants and prevention of malaria in Kenya. *International Journal of Environmental Research and Public Health*, 16(24), 5078. Retrieved August 12, 2024, from <https://www.mdpi.com/1660-4601/16/24/5078>
- Hilaire**, Hilaire, M. G. (2017). Climate Change and Malaria in Côte d'Ivoire: Social Representations and Knowledge of the Populations of Adjéyaokro (Bouaké). *European Scientific Journal*, ESJ, 13(26), 110. <https://doi.org/10.19044/esj.2017.v13n26p110>
- Hyma**, B., Ramesh, A., & Chakrapani, K. P. (1983). The situation of malaria control in the urban environment and environmental problems, Madras City, India. *Ecology of Disease*, 2(4), 321–335. John Libbey Eurotext. <https://books.google.com/books?hl=fr&lr=&id=qz1cXrXTFpwC&oi=fnd&pg=PA3&dq=factors,+socio+environmental,+transmission,+paludisme,+urban,+europe&ots=ImsP2-dII2&sig=aDPi7Kibuij4s-Qs-8eo0ojwVdY>
- Kaoudja**, A. (2022). Epidemioclinical, therapeutic and evolutionary profile of imported malaria in the infectious disease department at EPH Ouargla (2019-2021). [Thesis, Université Kasdi Merbah Ouargla]. <http://dspace.univ-ouargla.dz/jspui/handle/123456789/30828>
- Kouamé**, K. H., & Adou, D. L. Kafoudal Review. (Special Issue January 2020). Socio-demographic and environmental obstacles to the fight against malaria in Daloa (Ivory Coast). Department of Geography Jean Lorougnon Guédé University, Daloa (Ivory Coast). Retrieved from https://www.researchgate.net/publication/346443324_Revue_KAF_OUDAL_N_Special_Janvier_2020
- Labama** Otuli, N., Marini Djang'Eing'A, R., Losimba Likwela, J., Bosenge Nguma, J.-D., Maidu Alongo, M.-A., Ahuka Ona Longombe, A., Mbutu Mango, B., Bono M. N., D., Mokili L., J., & Manga Okenge, P. (2021). Efficacy and safety of mefloquine for malaria prophylaxis during pregnancy in Kisangani, Democratic Republic of the Congo: A randomized clinical trial. *British Journal of Clinical Pharmacology*. <https://doi.org/10.1111/bcp.14720>

- Ndeffo-Mbetse**, J. B., Njintang, Y. Y., Njintang, E. N., & Ndip, L. M. (2020). Considerations on the factors that contribute to the persistence of high malaria transmission in the forest areas of sub-Saharan Africa: The case of Mvoua, in South Cameroon | *Parasites & Vectors*. <https://link.springer.com/article/10.1186/s13071-020-04525-0>
- Okumu**, F., J., Gyapong, M., B., Casamitjana, N., et al., Guillaume, C., Cécile, A.-B., Chantal, & Agnès. (2022). What Africa can do to accelerate and sustain progress against malaria. *PLOS Global Public Health*, 2(6), e0000262. <https://doi.org/10.1371/journal.pgh.0000262>.¹ [https://psychaanalyse.com/pdf/COLLOQUE%20SANTE%20ET%20BIODIVERSITE%20SYNTHESE%20D%20ATELIER%202014%20\(10%20Pages%20-%2073%20Ko\).pdf](https://psychaanalyse.com/pdf/COLLOQUE%20SANTE%20ET%20BIODIVERSITE%20SYNTHESE%20D%20ATELIER%202014%20(10%20Pages%20-%2073%20Ko).pdf)
- WHO**. (2022). 2022 Annual Report of Activities to Combat Malaria.
- WHO**, J. (2021). Report of the Strategic Advisory Group on Malaria Eradication
- Ouédraogo**, A. S., Ouédraogo, J. S., Compaoré, I. K., Sanfo, G., Sanon, S., Some, S. N., & Dabiré, R. K. (2021). Risk factors for *Plasmodium falciparum* infection in pregnant women in Burkina Faso: A community-based cross-sectional survey¹ | *Malaria Journal*. <https://link.springer.com/article/10.1186/s12936-021-03896-8>
- Rasmane**, N. A. K., Tano, K. D., Koffi, J. A., & Yavo, W. (2023). Ethnobotanical study of plants used in the treatment of malaria in Abengourou, Côte d'Ivoire.
- Rudasingwa**, G., & Cho, S. I. (2020). Determinants of malaria persistence in Rwanda | *Malaria Journal*. <https://link.springer.com/article/10.1186/s12936-020-3117-z>
- Tairou**, F., Diallo, A., Sy, O., Kone, A., Manga, I. A., Sylla, K., Lelo, S., Fall, C. B., Sow, D., Ndiaye, M., Faye, B., & Tine, R. C. K. (2022). Malaria-associated risk factors among adolescents living in areas with persistent transmission in Senegal: A case-control study. *Malaria Journal*, 21(1), 193. <https://doi.org/10.1186/s12936-022-04212-8>
- Tomasi**, S., & Vanny, R. (2015). Environment and health: A geographic approach to malaria in Mondolkiri (Cambodia). *Environmental Dynamics. International Journal of Geosciences and the Environment*, 36, Article 36. <https://doi.org/10.4000/dynenviro.999>