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Urbanization and Malaria Transmission Dynamics in Sub-Saharan Africa: Challenges and Opportunities for Public Health Interventions

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ABSTRACT

Urbanization in sub-Saharan Africa (SSA) is rapidly transforming demographic and socioeconomic landscapes, impacting malaria transmission dynamics in complex ways. Despite historical assumptions that urban areas pose lower malaria risks, recent trends indicate increased transmission in these environments. This paper explores the epidemiologic patterns, determinants, and challenges of urban malaria in SSA, highlighting the influence of urban planning, vector ecology, population behavior, and environmental management. It also examines innovative public health interventions and vector control strategies tailored to urban settings. Understanding these dynamics is crucial for developing effective malaria control programs as urbanization continues to accelerate.

Keywords: Urban malaria, Sub-Saharan Africa, Urbanization, Vector control, Public health interventions and Malaria transmission

INTRODUCTION

Urban malaria transmission varies greatly between and within African urban areas, with epidemiologic patterns, time trends, and determinants influenced by heterogeneities in malaria risk (e.g, urban planning, ecology of malaria vectors and presence of potential breeding sites, population movement, and behavior driven by population density) [1-3]. Others, such as malaria outbreak and epidemic prediction and prevention, transmission, and vector bionomics, are currently relatively less understood due to a lack of attention, methodological data, and suitable study design and standardized metrics. The 3.5 billion people that are expected to become urban residents in SSA before 2050 will be at the forefront of vector-borne disease transmission risks. A number of environmental and climatic factors are expected to define the impact of urbanization on malaria, yet it is known that urban environments have reduced vector densities, and fewer opportunities for larval breeding sites due to improved, engineered water management [4-5]. Moreover, the conceptualization of the urban environment as a 'heat-island' feature and its effect on Anopheles breeding sites might often overlook the impact of seasonally optimized built-up water management by urban residents, such as drainage system maintenance, rainwater collection, and modern sanitation approaches, which may promote and extend larval breeding into the dry season. Within SSA malaria, incidence is the highest in peri-urban areas, which are common in coastal cities. Urban population in sub-Saharan Africa (SSA) has grown at unprecedented rate from 18.7% in 1980 to 40.9% in 2020, and it is expected to reach 56.8 % in 2050 [6-8]. This growing urbanization accelerates socio-economic development, together with public health progresses, the process accentuates the differences and changes in the spread and control of infectious diseases, including parasitic and vector-borne diseases such as malaria. To achieve malaria elimination and eventually zero transmission, program effectiveness and efficiency could be enhanced through proactive management of behavioral and environmental determinants of urban malaria risks with renewed emphasis on the need for strong leadership, community engagement, and collaborations in preparation for growing urban malaria populations [9-10].

Background and Rationale

Urbanization presents a complex set of challenges to public health and, with its rapid growth, is considered to be one of the greatest drivers in increasing health risks worldwide. The dense and often transient nature of urban populations tend to encourage the spread of infectious diseases, as cities provide ideal environments for pathogens to disseminate [11-12]. In addition they are often selective in the organization of their public health systems and services, major acute challenges such as dealing with outbreaks of infectious diseases, particularly when preventive measures fall below adequate levels. The rapid growth and density of urban populations in developing countries, combined with poor living conditions and inadequate public health infrastructure, create a favorable landscape for the spread of numerous infectious diseases like human immunodeficiency virus (HIV), major respiratory viruses, tuberculosis and other sexually transmitted diseases [13-14]. Malaria remains a major global health problem that has so far proved to be a difficult challenge for urbanization. Urbanization is often perceived as a process leading the successful elimination of rural malaria and thus holds promise as an additional lever for public health interventions [15-16]. Urban populations are rapidly increasing, with over 60% of the global population projected to live in urban areas by the middle of the century [17]. In sub-Saharan Africa, recent growth has been particularly dramatic, with the urban population projected to increase from around 375 million individuals in 2015 to more than 1.5 billion by 2050. Urbanization results in the permanent transformation of rural areas into urban zones, which impacts human and environmental systems. Numerous human interactions, activities, and socio-spatial patterns are formed and mediated within urban environments that were largely unseen in largely rural communities. Populations are denser in urban environments, often living in close quarters of high-story apartments or crowded slums. Urban areas also tend to be well served by transportation infrastructure including roads and public transportation, facilitating the rapid spread [1-4].

Urbanization Trends in Sub-Saharan Africa

Urbanization in SSA may bear positive as well as negative implications for the malaria risk environment and associated parasite transmission dynamics. Urbanization reduces building space, creating relatively reduced larval habitats in the form of diverse types of man-made containers (e.g., construction blocks, old tires, cans) which often collect water due to poor waste disposal practices. These container habitats, as they are transitory, in the main exhibit low species richness and supporting only well-adapted A. stephensi and A. albopictus vector species, both prolific despite low water quality levels and frequently found in highly urbanized settings. These adaptations, potentially synergized with new human-induced selection pressures that come with transitioning to polluted water bodies, stand to increasingly blur the boundary between 'rural' and 'urban' vector ecologies [5-6]. The continued rise and expansion of urban areas require a corresponding shift in vector control interventions beyond indoor manifestations to include water containers and other man-made breeding habitats in order to continuously reduce vector densities and keep malaria risk environment's intensity low, even as environmental modification (urban change) continues to occur. Rapid urbanization in Sub-Saharan Africa (SSA), home to over 1.1 billion people, is profoundly transforming the demographic and socioeconomic landscapes of the continent. By 2035, it is anticipated that 50% of the SSA population will be based in urban areas, representing a significant increase from the current 40% [7-8]. Reflecting population growth and heightened densities, the combined number of SSA metropolitan areas is anticipated to reach close to one hundred by 2025, a 60%growth in comparison to 2010 [9]. SSA cities, especially those of smaller size and lower population densities, are undergoing the most substantial changes, recording an average annual population growth of 5% between 2010 and 2020. For the most part, in these cities, such expansion outstrips development and insufficient planning, leading to the emergence of informal settlements in which infrastructure and services such as housing, water and sanitation, education, and health systems tend to lag behind [9].

Factors Driving Urbanization

Across the world, cities have more demographic and health data than rural areas, and yet the health challenges of urbanization, especially in sub-Saharan African cities, present a long-term health challenge [11]. Urbanization can also lead to the emergence of diseases due to the intermingling of various people, species, and complex ecosystems under conditions of rapid demographic and social change, traffic and trade, and poor sanitation [13]. Nairobi, Lagos, and Kinshasa are emblematic examples of this challenge. Understanding the environmental, social and biological factors driving disease emergence and spread in developed urban areas is of paramount importance for developing and implementing public health interventions to mitigate the spread of certain epidemics. The intensification of urbanization has been fueled by various factors, such as rural to urban migration, natural urban population increment, faster urban population growth than rural population growth, and government policies to decentralize industry and urbanize certain regions [9]. One out of two people now live in cities and the extension of this trend can lead to higher population densities in urban areas, particularly in low-income cities and slums [5]. Urbanization in sub-Saharan Africa is rapid and the region now has the largest urban growth rates and the highest urban population growth rates of all developing areas [7]. The United Nations (UN) projects indicate different predictions by 2030: two third of Africans (58 % in 2020) will live in cities.

Malaria Epidemiology in Urban Settings

In recent years, there has been growing realization that, in the context of un-or under-regulated urbanization, rapid expansion of urban environments is creating challenging, unplanned, and complex urban malaria transmission dynamics. Alongside these developments, theoretical modeling has demonstrated that, in the absence of efficient mosquito control and high-quality healthcare access, high levels of immunity amongst urban populations can paradoxically lead to higher-than-expected local transmission potential given the abundance of endophagic vectors and the development of indoor subpopulations of these vectors in urban environments even when homes remain closed during the day. Malaria in modern sub-Saharan urban central business districts (CBDs) has been reported for more than 20 years and trenchant malaria transmission associated with urban agriculture, waste and stormwater pooling, field irrigation, water storage, and construction projects is documented in several East African cities such as Dar es Salaam, Nairobi, and Kampala. Each year, there are more than 200 million cases of malaria reported around the world, with resultant risk factors and burdens, and a greater than 90 percent mortality rate primarily attributable to infections occurring in sub-Saharan Africa (SSA) [7]. More than half of the world's population presently resides in cities, and SSA is the fastest urbanizing region globally, with more than half of the world's urban population growth anticipated to occur there over the next two decades. Of the 10 fastest growing cities in the world, 6 are located in SSA. Historically, urban areas have been considered lower-risk areas for malaria transmission, particularly in comparison to rural areas, due to a variety of host, parasite, and vector factors that increase transmission in the latter environments (e.g., high penetrance of Anopheles spp. vectors) and decrease it in urban environments (e.g. vector bionomics, altered human behaviors such as increased use of bednets indoors, and financial barriers to pyrethroid-resistant vectors) [11].

Comparison with Rural Areas

The author further provide a theoretical understanding of the epidemiology of malaria discussing the great progress that has been made in understanding why the control of malaria is so difficult. One of the most important reasons is the high prevalence of malaria asymptomatic carriers who do not seek treatment and may thus constitute a reservoir of infection. This makes transmission very efficient. The impact of anti-malaria control measures such as the long-lasting insecticide-treated mosquito nets is currently limited. However, alternatives to these control strategies exist: anti-malarial rapid diagnostic tests as a malaria infection-resource identification tool and interventions such as mass chemotherapy, mass screening and treatment, and mass drug administration. As a conclusion, the use of mathematical models of malaria transmission would help to plan and evaluate control and elimination strategies by considering aspects of the malaria epidemiology that are not always considered. In fact, it was the methods used to calibrate the model, and the definition of the most important parameters that should trigger model improvement [7] Eradication of malaria by 1970s failed because of inadequate knowledge on vectors, intervention strategies, and the evolution of vector insecticide resistance. We describe the development and evaluation of new vector and parasite surveillance and tools for targeted interventions in urban areas. We have uniformly monitored colonization of the urban ecology by A. gambiae sensu lato, dominant complex, and other potential minor urban vectors in the three study sites of the Ouagadougou HDSS. Urbanization has led to a profusion of semi-natural mosquito habitats where A. gambiae s.l. has become highly abundant. The adaptation to the urban environment has partly led to the loss of microbial diversity among the dominant species of the A. gambiae complex reflected as lower fecundity in their offspring. The attraction of malaria vectors to human beings was different between the dominant main malaria vector (A. coluzzii) and a newly established one (A. gambiae s.s.) in the study sites, which has consequences on the intensity and the spatial structure of the urban malaria transmission in Ouagadougou [7] Studies from both urban and rural sites in the Ouagadougou area of Burkina Faso revealed that malaria is a year-round disease with different patterns of intensity in the two types of environments [9]. Microstratification of urban areas based on land cover, together with knowledge on the biology of the main malaria vector Anopheles gambiae, helped us to disentangle the effect of urbanization on vector density and mortality rate. It also revealed high heterogeneity of demographic and malariometric risks at small spatial scale (1 km) in the town, leading to the development of segment-wide control intervention such as indoor insecticidal residual spraying. Approaches for community-based interventions targeting high and medium-risk populations were discussed with key stakeholders in Burkina Faso [7].

Challenges and Opportunities for Malaria Control in Urban Areas

There are a number of challenges to improving urban malaria control; but also unique opportunities that are already being leveraged. Learning from these challenges and solutions will be necessary in order to create the comprehensive strategies needed to address the diverse urban malaria settings that will emerge over the next 20 years. Because of the relatively-recent occurrence of large city slums, most of the research on management has been focused in Southeast Asia, Latin America, and Middle income urban areas, rather than less developed, rapidly growing, African cities. City fever strategies avoid insecticide treatment in households, which is significantly more expensive, logistically complex, and less effective in African urban than elsewhere. These strategies will not have the some impact in all urban areas; local epidemiological and entomological conditions will affect Vector Control Program strategies most. All urban areas will require other SOPs that leverage these same activities. Urban areas play an increasingly important role in the national and global dynamics of mosquito borne disease transmission [6]. The unique characteristics of urban environments affect community structure, in an environment comprised of a mix of long-term residents, recent migrants, and itinerant workers. New African city dwellers have a higher prevalence of infection than long-term city residents and their more rural counterparts [7]. Similar patterns have been observed in Asian cities and particularly for dengue in Latin American cities. There is also evidence that insecticide resistance in mosquito vector species, such as Anopheles gambiae s.l. and Aedes aegypti, is evolving faster in urban areas than it is in surrounding rural areas and is highly resistant to multiple classes of insecticides [8]. Furthermore, a number of efficiently managed vector control programs, and many haven't had the same impact in urban areas as they have in their rural counterparts. The close proximity of individuals in urban areas, necessary for the sustainability of these programs, also restricts the efficacy of the spraying buildings and spraying within households advocated as the main control options in rural areas.

Health System Infrastructure

Urban planning and the presence of water and sanitation facilities play an important role in facilitating vector control. Dakar unequal environmental features may also lead to different malaria transmission dynamics in different areas. Malaria is no longer considered a disease of rural environments only but that it continues to be a significant health problem in cities, where a large portion of the population is living. In the least developed countries, primary prevention methods that are essential in controlling vector-borne diseases are not yet well developed. Indeed, the lack of infrastructure in the urban areas makes it difficult to monitor and control the breeding of Anopheles. Evaluating a health system, its infrastructure, and its response to infectious diseases ensures improvement and implementation where necessary, particularly in urban settings [6]. A proper health system is an important part of national economic development as it promotes a population's economic growth and reduces poverty. In Senegal, a weak community and primary health care infrastructures and interventions were a significant limitation in controlling malaria [8]. Geographical access to health care and socio-economic status, including both urban and rural settings must all be taken into consideration. In addition, the implementation of DTL in Senegal benefits from a well-organized network, a dense population and a high health service availability, where each health post provides access to care for 5000 people [9]. Yet, some limitations are still present, because trained community actors are scarce and health care professionals are not able to provide care on a 24/7 basis.

Innovative Public Health Interventions

In high urban (I-III) and peri-urban areas, adult malaria incidence is at 2.8 and 0.5/10 adult/year respectively and falls to the potential elimination threshold of 0.001/10 habitant/year in type IV city centers. In these urban areas, when relying on local human donors for auto-dissemination, An. coluzzii need to breed outside of traditional breeding sites, reinforcing the risk to develop outdoor and resistant populations. These results open a discussion upon the continuous usage of human spatial repellents, the shift towards innovative public health interventions as theoretical seasonal larval control, and the monitoring of the susceptibility to Pyrethroids of An. coluzzii populations at all urban latitudes [8]. In type I-III African cities, transmission is more perennial because breeding sites are continuous due to better access to hospital environment and household water within the boundary of the constructed space; these zones need to be continuously protected with vector control and be the targets of more innovative public health interventions. Within cities, the need to target specific traditional seasonally used breeding structures at specific times has been emphasized to complement usual auto-dissemination efforts conducted through human spatial repellents. Moreover, innovative targeted surveillance through. AI applied to ecological facts, apt to be implemented in all environments but relying on a high density of breeding sites, should be useful, given the permissibility of African mosquito generalist species (parasites in the human blood) [6]. Urban and suburban areas of tropical African cities are often more conducive to Anopheline production, mainly due to poor urban environmental management and exacerbation by more frequent and deleterious rainfalls, poor waste and water management and deterioration of ecological networks. In type IV African cities that have only recently reached urban density and are generally less expanded than older cities. Here, transmission is highly variable and localized based on the ability of the human populations to maintain breeding sites in and around housing during the dry season in the absence of ecological sites, such as within constructed ecotones or within construction. If containment and control are agile with reactivity of human population to optimize them, small seasonal malaria fever surges of limited public health impact are possible [5].

Vector Control Strategies

World Health Organization (WHO) guidelines recommend the use of Integrated Vector Management (IVM) tools for malaria control and eradication. Applications of adulticides indoors and larviciding within easily accessible and productive urban settings may be a great strategy in the fight against malaria in African cities. In light of this, if programs are to achieve reduction in malaria infections, both indoor and outdoor vector control tools must become a focal point. One key solution to increasing outdoor and early evening contact is the implementation of control strategies targeting both larval and adult stages of all mosquito vectors within the urban to peri-urban environment. This strategy is great particularly for urban settings. Evidence from a 5 year-old larvae survey in Dar es Salaam, Tanzania showed a key intervention targeting mosquito larvae in the environment reduced malaria prevalence by 20%. Larvae control initiatives can further be enhanced by focusing on local areas for maximum health impact, with technical expertise and community support. Vector control is an important strategy for the reduction of malaria transmission in endemic regions [8]. The existing malaria control programs throughout Africa target mosquito vectors using indoor insecticides and mosquito nets with the assumption that the control of vectors indoors is the key to the reduction and prevention of malaria transmission [8]. However, there is mounting evidence of increasing outdoor malaria transmission hence the need for a shift in mosquito-vector control programs to include outdoor interventions in combination with existing methodologies to reduce transmission catalyzed by the increased exophagy and exophily of the local mosquito vectors [8]. Such increased outdoor and early evening contact of mosquito vectors with humans is expected to exacerbate the effect on malaria transmission.

CONCLUSION

Urbanization in SSA presents both challenges and opportunities for malaria control. The increasing urban population necessitates proactive management of behavioral and environmental determinants of malaria risk. While urban environments generally reduce vector densities, unique urban features can sustain malaria transmission. Effective malaria control in urban settings requires tailored strategies that address both indoor and outdoor transmission, leveraging innovative public health interventions and community engagement. Understanding and addressing the dynamic nature of urban malaria transmission is essential for achieving malaria elimination goals in the context of rapid urban growth.

REFERENCES

1. Cottrell, G., Kouwaye, B., Pierrat, C., Le Port, A., Aziz, B., Fonton, N., Massougbodji, A., Corbel, V., Norbert Hounkonnou, M., & Garcia, A. (2016). Modeling the Influence of Local Environmental Factors on Malaria Transmission in Benin and Its Implications for Cohort Study. [PDF]
2. Lover, A. (2015). Epidemiology of Latency and Relapse in Plasmodium vivax Malaria. [PDF]
3. Tatem, A. J, W Gething, P., L Smith, D., & I Hay, S. (2013). Urbanization and the global malaria recession. ncbi.nlm.nih.gov
4. Inoue, M. & Gupta, V. (2018). Weak Control for Human-in-the-loop Systems. [PDF]
5. A Sattler, M., Mtasiwa, D., Kiama, M., Premji, Z., Tanner, M., F Killeen, G., & Lengeler, C. (2005). Habitat characterization and spatial distribution of Anopheles sp. mosquito larvae in Dar es Salaam (Tanzania) during an extended dry period. ncbi.nlm.nih.gov
6. Doumbe-Belisse, P., Kopya, E., S. Ngadjeu, C., Sonhafouo-Chiana, N., Talipouo, A., Djamouko-Djonkam, L., P. Awono-Ambene, H., S. Wondji, C., Njiokou, F., & Antonio-Nkondjio, C. (2021). Urban malaria in sub-Saharan Africa: dynamic of the vectorial system and the entomological inoculation rate. ncbi.nlm.nih.gov
7. Ye, Y., Madise, N., Ndugwa, R., Ochola, S., & W Snow, R. (2009). Fever treatment in the absence of malaria transmission in an urban informal settlement in Nairobi, Kenya. ncbi.nlm.nih.gov

8. Modu, B., Polovina, N., & Konur, S. (2020). Agent-Based Modelling of Malaria Transmission Dynamics. [PDF]
9. Mangani, C., Mzilahowa, T., Cohee, L., Kayange, M., Ntenda, P., Sixpence, A., Gumbo, A., Lankhulani, S., Goupeyou-Youmsi, J., Walker, E., Laufer, M., Valim, C., Seydel, K., L. Wilson, M., Taylor, T., & P. Mathanga, D. (2022). Malawi ICEMR Malaria Research: Interactions and Results Influencing Health Policies and Practices. ncbi.nlm.nih.gov
10. Wilson, L. M., J. Krogstad, D., Arinaitwe, E., Arevalo-Herrera, M., Chery, L., U. Ferreira, M., Ndiaye, D., P. Mathanga, D., & Eapen, A. (2015). Urban Malaria: Understanding its Epidemiology, Ecology, and Transmission across Seven Diverse ICEMR Network Sites. ncbi.nlm.nih.gov
11. Kalapotharakos, C., Brambilla, G., Timokhin, A., K. Harding, A., & Kazanas, D. (2017). 3D Kinetic Pulsar Magnetosphere Models: Connecting to Gamma-Ray Observations. [PDF]
12. J Donnelly, M., McCall, P. J., Lengeler, C., Bates, I., D'Alessandro, U., Barnish, G., Konradsen, F., Klinkenberg, E., Townson, H., Trape, J. F., M Hastings, I., & Mutero, C. (2005). Malaria and urbanization in sub-Saharan Africa. ncbi.nlm.nih.gov
13. Machault, V., Vignolles, C., Pagès, F., Gadiaga, L., Gaye, A., Sokhna, C., Trape, J. F., Lacaux, J. P., & Rogier, C. (2010). Spatial heterogeneity and temporal evolution of malaria transmission risk in Dakar, Senegal, according to remotely sensed environmental data. ncbi.nlm.nih.gov
14. Feged-Rivadeneira, A., Angel, A., González-Casabianca, F., & Rivera, C. (2017). Malaria intensity in Colombia by regions and populations. [PDF]
15. Machault, V., Gadiaga, L., Vignolles, C., Jarjaval, F., Bouzid, S., Sokhna, C., Lacaux, J. P., Trape, J. F., Rogier, C., & Pagès, F. (2009). Highly focused anopheline breeding sites and malaria transmission in Dakar. ncbi.nlm.nih.gov
16. Dudley, H. J., Goenka, A., J. Orellana, C., & E. Martonosi, S. (2015). Multi-year optimization of malaria intervention: a mathematical model. [PDF]
17. Chaki, P., J Govella, N., Shoo, B., Hemed, A., Tanner, M., Fillinger, U., & F Killeen, G. (2009). Achieving high coverage of larval-stage mosquito surveillance: challenges for a community-based mosquito control programme in urban Dar es Salaam, Tanzania. ncbi.nlm.nih.gov

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