Environmental Factors and Urban Malaria Transmission Risk in sub-Saharan Africa: Implications for Public Health Policy

Okangba, C.C

Department of Medical Microbiology and Parasitology, Benjamin Carson School of Medicine, Babcock University Ilisan-Remo, Ogun-State, Nigeria.

Abstracts: - **Malaria remains the most complex and overwhelming health problem in sub-Saharan Africa (SSA). Malaria not only remains a leading cause of morbidity and mortality, but it also impedes socioeconomic development, particularly in sub Saharan Africa. The rapid increase in the world's urban population which has led to uncontrolled and unsustainable exploitation of natural resources and has major implications for the epidemiology of malaria. Sub-Saharan Africa suffers by far the greatest malaria burden worldwide and is currently undergoing a profound demographic change, with a growing proportion of its population moving to urban areas. A review of malaria transmission in sub-Saharan African cities shows the strong likelihood of transmission occurring within these sprawling cities, whatever the size or characteristics of their bio-ecologic environment. Factors affecting malaria transmission are going hand-in-hand with often declining economies might have profound implications for the epidemiology and control of malaria, as the relative disease burden increases among urban dwellers. Urbanisation is generally expected to reduce malaria transmission; however the disease still persists in African cities, in some cases at higher levels than in rural areas. Malaria control in urban environments may be simpler as a result of urbanization and urban malaria is highly focused; however, much of what we know about malaria transmission in rural environments might not hold in the urban area context. Global public health interventions may not be reaching poor and less privileged populations, therefore, there is need to examine the differences in the burden of disease and the coverage and impact of public health interventions among persons with differing socioeconomic status.**

Key words: **Malaria, sub-Sahara Africa, transmission, urbanization, social and economic status, health**

I. INTRODUCTION

Malaria remains the most complex and overwhelming health problem, facing humanity with 300 to 500 million cases and 2 to 3 million deaths per year (WHO, 2010). About 90% of all malaria deaths in the world today occur in sub-Saharan Africa and this is because majority of infections are caused by *Plasmodium falciparum*, the most dangerous of the five human malaria parasites (*P. falciparum, P. ovale, P. vivax, P.malariae, P. knowlesi*), accounting for an estimated 1.4 to 2.6 million deaths per year in this region (Steketee *et al.,* 2001). In addition, the most effective malaria vector- the mosquito *Anopheles gambiae* is the widest spread in the region and the most difficult to control (WHO, 1990) . In some areas of sub-Saharan Africa people receive 200 to 300 infective bites per year (UN,2001).The vector population in sub-Saharan Africa is uniquely effective, with the six species of the *Anopheles gambiae* complex being the most efficient vectors of human malaria in the region, and often considered the most important in the world. *An. funestes* is also capable of producing very high inoculation rates in a wide range of geographic, seasonal, and ecological conditions (Chinery, 1984; Awolola *et al.*, 2007).

These vectors have proven effective in transmitting the malaria parasite to humans across the region, in rural and urban areas alike. *An. pharoensis* is also widely distributed in Africa, geographically and ecologically, and can maintain active transmission of malaria even in the absence of the main malaria vectors (Janssen and Wery,1987). Malaria in sub-Saharan Africa is a problem of dimensions unlike those seen anywhere else in the world today. The magnitude of malaria in the region is affected by a variety of factors, none of which addressed alone is likely to effect a resolution. It is further compounded by the generally poor social, environmental and economic conditions in sub-Saharan Africa (Jennifer *et al.*, 2004).

In 2005, WHO proposed a goal to reduce the incidence of malaria, caused by *Plasmodium* infection, in endemic regions by 75% by 2015 (WHO, 2015). In order to achieve this goal, between 2000 and 2015, a number of malaria control measures were implemented in regions where transmission of the disease was high. These control measures caused a 37% decrease in incidence, and a 60% decrease in the mortality rate (6.2 million lives saved) related to the disease (WHO, 2015). However, malaria remains a common public health problem in developing countries. In 2016 alone, approximately 216 million people were infected, and an estimated 445,000 died due to malaria globally (WHO, 2015). About 90% of these malaria cases and 91% of deaths due to the disease were in sub-Saharan Africa (WHO, 2018). Moreover, in 2013, post-natal mortality from malaria in SSA was estimated to be 437,000 (WHO, 2015). More than 70% of

deaths due to malaria in SSA in 2016 occurred in children under five (WHO, 2015). The presence of insecticide resistant mosquitoes (complex) and favorable climate and environmental conditions, conducive to vector survival, makes malaria transmission high in SSA (Da Silva and Marshall, 2012; Alonso and Tanner, 2013; Griffin *et al.,* 2014). Moreover, *P. falciparum*, which contributes to severe symptoms and high death rates, is the most dominant species in SSA (Griffin *et al.,* 2014; Snow, 2015). Furthermore, socioeconomic factors including education, employment, income, and household likely may contribute to the high burden of malaria in SSA (Cooseman's *et al.,* 1992). Poorly constructed houses allow easy entrance of *Plasmodium*-carrying vectors and increases chances of infection among family members (Lindsay *et al.,* 2003). Individuals with low income cannot easily afford to buy chemicals to spray in the houses, insecticide treated bed nets (in countries where not provided for free), and drugs or other related medical costs (Macintyre *et al.,* 2002; Njama *et al.,* 2003; Tamiro *et al.,* 2000). Lack of education also may be related to low levels of awareness about malaria prevention and treatment strategies (Ricci *et al.,* 2012).

Urbanization has a significant impact on the economy, lifestyles, ecosystem and disease patterns including malaria (Hay *et al.,* 2005; Omumbo *et al.,* 2005). The rapid increase in the world's urban population has major implications for the transmission and epidemiology of malaria and other vector-borne diseases (Lines *et al.,* 1994; Warren *et al.,* 1999; Donnelly *et al.,* 2005; Wang *et al.,* 2006) An estimated 39% of the population in SSA lived urban areas in 2003(UN, 2003). 198 millions Africa lived in urban malaria endemic areas and 24-103 million clinical attacks occur annually in those areas (Keiser *et al.,* 2004).The epidemiology of urban malaria poses a number of specific challenges namely:Late/ delay in acquisition of semi immunity against malaria infection (Trape, 1987), the intensity of the malaria risk is often heterogeneous over small distance, being subjected to the degree of urbanization of particular sub-division (Robert *et al.,* 2003) and their proximity to possible vector breeding sites (Trape *et al.,* 1992; Staedke *et al.,*2003), rural-urban migration is likely to increase the endemicity of malaria (Benyoussef *et al.,*1996), agricultural and animal husbandry are important economic activities which create a favourable environment for Anophele breeding (Robert *et al.,* 1998; Afrane *et al.,* 2004), marginalized populations usually lacks access to health care, which hampers the effectiveness of case management and the promotion of intermittent antimalaria during pregnancy (Sanon *et al.,* 1990; Noor *et al.,*2003;Donnelly *et al.,* 2005).

Despite the severity of the problem, gaps remain concerning urban malaria transmission in SSA (Wang *et al.,* 2006). Several explanations exist to account for why urban areas seem to have lower malaria transmission rates compared with rural areas. One explanation is that pollution affects larval habitats, the life cycle of mosquitoes, and vectorial capacity (Keiser *et al.,* 2004; Wang *et al.,* 2006; Awolola *et al.,* 2007).

Other explanations include mosquito avoidance behavior by urban populations, such as screens, doors, insecticides, and bed nets. Higher human population densities may reduce biting rates, owing to the higher ratio of humans to mosquitoes. Few data are available to confirm these theories or to prioritize strategies for malaria control (Keiser *et al.,* 2004; Wang *et al.,* 2006; Baragatti *et al.,* 2009).

II. BACKGROUND INFORMATION

Malaria remains a major public health problem that affects 106 countries worldwide mostly in tropical and subtropical regions where ~3.4 billion people are at risk of infection and death (WHO, 2015). Although malaria is mainly transmitted in rural areas where there are suitable environments for Anopheles mosquitoes breeding sites, malaria transmission in urban areas of endemic countries has been increasingly reported over the last three decades (Robert *et al.,* 2003: Keiser *et al.,* 2004). Unfortunately, the factors driving urban and peri-urban malaria transmission remain poorly characterized. As urban malaria cases are likely to be found at a broader range of primary care/diagnostic facilities, including hospitals and private laboratories failing to report them to the central surveillance system (Donnelly *et al.,* 2005; Tada *et al.,* 2007; Wilson *et al.,* 2015), urban malaria control by National Malaria Control Programs (NMCP) requires important administrative changes. Like other epidemiological settings, urban malaria transmission is influenced by population movements from rural to urban and peri-urban areas. This rural population influx into urban and peri-urban areas facilitates the introduction of malaria from places where the disease is of urban versus peri-urban *P. vivax* transmission in high prevalence such as those where illegal mining and logging are common(Castellarios *et al.,* 2016). Furthermore, these underserved populations practice subsistence farming and inhabit poor housing with limited access to health services; such social dynamics favor mosquito breeding in areas considered administratively urban (Padilla *et al.,* 2015)

Malaria continues to be the most significant mosquito-borne disease globally but it holds a particularly heavy burden across many countries in Africa where in 2015, 88% of global cases and 90% of global deaths due to malaria were recorded (WHO, 2016). With declines in *Plasmodium falciparum* malaria transmission, largely due to increased distribution of longlasting insecticide-treated nets (LLINs) and a switch to artemisinin-based combination therapy (ACT) drugs, sub-Saharan Africa still suffers greatly from the disease (Oreagba *et al.,* 2004; Ukpong *et al.,* 2007; Okeke and Okafor, 2008). According to World Health Organization (WHO) estimates, in 2010, of the 655,000 deaths attributed to malaria worldwide, 91% of these were in Africa (WHO,2002). At the same time, Africa's demography is rapidly changing, with an increasing number of people moving to urban areas. In West Africa, the population growth rate for urban areas is estimated at 6.3%, which is more than double the total population growth rate (Donnelly *et al.,* 2005), and it is predicted that, by 2035, the urban population of sub-Saharan Africa will outnumber the

rural one (Parnell and Walawege, 2011). As Africa becomes increasingly urbanized, factors contributing to urban malaria will become more relevant (WHO, 2008; Saugeon *et al.,* 2009).

The general consensus is that urbanization will lead to decreased malaria transmission. One recent modelling study predicts a 53.5% reduction in malaria transmission by 2030, largely due to expected demographic changes (Saugeon *et al.,* 2009). It is thought that urbanization leads to improved infrastructure, better-quality "mosquito-proof" housing, increased access to healthcare, and a reduction in vector breeding sites. Malaria vector species are known to prefer clean water for breeding, which is difficult to come by in polluted urban areas, and the higher ratio of humans to mosquitoes is also thought to lead to a decreased human biting rate (Winkenberg *et al.,* 2008). However, despite these encouraging factors, malaria transmission persists in African cities and, in some cases, at even higher levels than in surrounding areas (Matthys *et al*., 2006). Indeed, there are African cities experiencing entomological inoculation rates (EIRs) greater than 80 infective bites per person per year (Mourou *et al*., 2012). A variety of factors may contribute to this, including socioeconomic status, such as education level, wealth, house structure, urban agricultural practice and poorly-monitored land use (Baragatti *et al.,* 2009; Stoler *et al.,* 2009).

Existing literature reports heterogeneous results concerning the effect of house structure, education level, occupation, income, and wealth on malaria. Two previous reviews summarized information about the relationship of malaria with socio economic status (SES) worldwide (Tusting *et al*., 2013; Tusting *et al.,* 2015). However, the relationship of malaria with wealth (Tusting *et al.,* 2013) and house (Tusting *et al*., 2015) only and did not consider other SES indicators. In addition, the review by Tusting et al. (2013) (Tusting *et al.,* 2015) involved children up to 15 years of age only, and the meta-analysis was limited to comparisons between the least poor (highest) and poorest (lowest) wealth groups. Although the majority of deaths due to malaria occur in children, a considerable proportion of adults also experience malaria infection as well as related morbidities and deaths (Murray *et al.,* 2010; Nkumama *et al.,* 2017). Adults also can serve as a reservoir/source of infection for malaria in children by carrying low density parasites for long periods (Nkumama *et al.,* 2017). Moreover, the impact of SES indicators on health may vary across different population age groups (House *et al.,* 1990; House *et al.,* 1994). Thus, knowing the socioeconomic risk factors of malaria in adults would be useful in designing strategies to control the disease in this population. As various SES indicators may measure different aspects of health risk related to malaria, a systematic examination of the relationship of a variety of SES indicators separately with malaria is important to better understand the indicators that can explain malaria risk and recommend appropriate malaria prevention strategies accordingly. In addition, while Tusting et al. (2015) (Tusting *et al.,* 2015) reviewed literature on the

effects of housing structure on malaria risk that were published before 2014, several new articles have been published on the topic since. Thus, updating the literature on the subject is warranted to continue to inform policies related to malaria prevention and control measures in endemic regions.

Uncontrolled urban expansion can lead to increased malaria transmission as town planners are unable to keep up with sprawling city boundaries and rural practices, which are conducive to vector breeding sites and incorporated into the urban fringes (Donnelly *et al*., 2005; Baragatti *et al*., 2009). Furthermore, areas of low socioeconomic status, often at the periphery of cities, are at particular risk (Chima *et al.,* 2003). Here, poor-quality housing, unpaved roads, and reduced access to healthcare provide little protection against the disease (Mwangangi *et al*., 2012). A number of systematic reviews have investigated the impact of urbanization on malaria transmission in SSA (Hay *et al.,* 2005), dividing transmission into urban, periurban, and rural settings. However, urban malaria transmission varies according to a number of additional factors such as location (e.g., altitude, proximity to a sea, river, or floodplain), climate, land use, human movement patterns, socioeconomic factors, local vector species, vector breeding sites, waste management, and local malaria intervention programs (Stoler *et al*., 2009).

III. DEMOGRAPHIC CHANGES AND MALARIA TRANSMISSION

The demographic changes that we experience today are profound. Rapid urbanization alters the frequency and transmission dynamics of malaria, with significant effects on disease-associated morbidity and mortality, which in turn has important implications for control (Robert *et al*., 2003). At present, the least developed countries experience the highest urbanization rates, often in the range of 2–6% per year (UN, 2002). Until recently, urban development was generally believed to reduce the risk of vector breeding, and thus malaria transmission (Chinery, 1984). However, many African countries have declining economies, and most cities are struggling to cope with the pace and the extent of urbanization (Hay *et al.,* 2005; Okeke and Okafor, 2008). Poor housing and lack of sanitation and drainage of surface water can increase vector breeding and human vector contact, and thuspose unique challenges for control (Marten and Hall, 2000). Furthermore, the adaptation of malaria vectors to urban areas has been well documented for at least two decades, (Chinnery, 1984) and local transmission has been conclusively demonstrated in many African cities (Robert *et al*., 2003).An additional problem on the human side is that a high proportion of the urban population may be at risk of severe disease due to delayed acquisition or lack of protective immunity.

Quantitative assessment of the malaria burden in urban areas together with information on socially and environmentally sound and cost-effective intervention strategies are urgently

required (Alaba and Alaba, 2006). These data will provide a rational basis for the design, implementation, and monitoring of malaria control programs (Hutubessy *et al.,* 2001). Especially in urban environments a high degree of heterogeneity is observed: urban dwellings typically offer a relatively narrow spectrum of focal breeding sites (Wang *et al.,* 2006: Baragatti *et al.*, 2009). These sites are often straight forward to identify and to access, providing opportunities to spatially targeting interventions (Carter *et al.*, 2000). A great impact on urban malaria could be achieved by eliminating key risk sites. Consequently, techniques of environmental management, particularly surface water management, within the frame of an integrated control approach, offer potentially sustainable methods to substantially reduce transmission (Tilaye and Deresa, 2007).

IV. DEFINING URBAN

There is no consensus or commonly accepted definition of urban has been used by international bodies, national or local governments, planners or policy makers, let alone by health scientists (Vlahov and Galea, 2002; Tatem and Hay, 2004). United Nations Population Division data for 228 countries indicate that 108 use administrative definitions (e.g., city resident) to define urban, 51 use population density (e.g., people per square kilometer), and 39 use functional characteristics (e.g., extent of non-agricultural economic activity), whereas no definition exists for 22 and 8 classify either all or none of their citizens as urban (Hay*et al*., 2005) Thus, because each national Demographic and Health Survey relies on that country's National Statistical Office for their definition of urban, it is difficult to compare with other countries because of such differences. Urban communities have been defined by characteristics such as population number, density within specific geographic areas, or ensembles of people with governance responsibilities. For example, a settlement in Uganda with more than 100 people is classified as urban, while urban locales in Nigeria are those with more than 20,000 inhabitants (UN, 2001). Alternatively, settings in Ethiopia with at least 2,000 people are classified as urban, whereas in Botswana urban areas include agglomerations of at least 5,000 inhabitants, most of whom depend on non-agricultural activities (Phillips, 1993). These examples are all from SSA.

However, similar lack of clarity and consistency is seen in Latin America, Asia, and other regions. In addition, efforts to quantify or compare urban and rural malaria have begun to explore various complex metrics that view this false dichotomy as a continuum (Dahly and Adair, 2007).

V. DEFINING URBAN MALARIA TRANSMISSION

There is evidence of human infection among urban residents is important, the critical need is to determine how much "local transmission" is ongoing in and around urban dwellings (Wilson *et al.,* 2015). To help focus and design better interventions, it is essential to know whether people are being infected in the urban areas where infection and disease are being diagnosed. If not, then information on travel histories becomes critical to determining activities and locations of risk (Wilson *et al.*, 2015).Urbanization leads to many challenges for global health and the epidemiology of infectious diseases. New megacities can be incubators for new epidemics, and zoonotic diseases can spread in a more rapid manner and become worldwide threats (Neiderud, 2015). For infections that are acquired in urban settings, it is then important to understand when and where transmission is occurring and how urban transmission may differ from that in rural settings. In particular, it is crucial to characterize and understand how urban microhabitats promote Anopheles vector abundance and influence their behaviour of biting humans (Wilson *et al.*, 2015).

Urban microclimate variables (e.g., temperature, relative humidity, and precipitation) are also crucial to mosquito survival, reproduction, and development, thereby influencing vector presence and abundance in urban environments (Cator *et al.,*2013). Beyond vector abundance, house construction, insecticide treated net (ITN) use, and other factors that influence human–vector contact represent important factors in transmission risk. Similarly, an understanding of the amount of spatial variation that exists in urban areas with *Plasmodium* transmission and its magnitude are essential for knowing what kinds of control or prevention efforts should be undertaken in those settings. A recent systematic review of factors contributing to *Plasmodium* transmission in urban areas of SSA (De Silva and Marshall, 2012) evaluated more than 100 peer-reviewed studies from throughout the subcontinent. Most of these studies documented that cases were being steadily recorded in urban settings, at a surprisingly high incidence, although malaria incidence in urban areas was typically lower than in the surrounding rural settings. However, lower incidence in high population urban areas may represent a large number of urban malaria cases. Fewer studies have documented the vector-related characteristics (breeding sites, suitable environments, among others) found in these urban environments (Wilson *et al.*, 2015; Degarege *et al.*, 2019).

VI. URBANIZATION IN AFRICA

The world is becoming more urban every day, and the process has been ongoing since the industrial revolution in the 18th century. The United Nations now estimates that 3.9 billion people live in urban centres. The rapid influx of residents is however not universal and the developed countries are already urban, but the big rise in urban population in the next 30 years is expected to be in Asia and Africa. The classification of urban environments is by no means uniform. Urban communities maybe defined by physical borders, population size, geographic limits associated with administrative responsibilities, or governance (Silimperi, 1995; Wang *et al.,* 2006). In Botswana, for example, urban areas are defined as agglomerations of 5,000 or more inhabitants, with the majority depending on non-agricultural activities (Goodman *et al*., 2000). In Ethiopia, however, localities of 2,000 or more

people are classified as urban, and in Malawi all townships, town planning areas, and all district centres are defined a surban (Philip, 1993; Donnelly *et al*., 2005). Usually in habit ant sat the urban fringe are not included in the urban statistics because they are not part of a legally proclaimed area, although these areas often experience the highest population growth rates(Goodman *et al.,* 2000). In Africa, many cities were developed as colonial administrative or trading centres rather than industrial and commercial zones equipped to support large populations (Trape, 1987). Urban authorities have often been unable to keep up with the rapid growth of squatter communities and shantytowns (Felix and Class, 2005). Furthermore, stagnating and declining economies have often led to a decrease in the quality of the urban environment and deterioration in both the quality and distribution of basic services, including housing and medical facilities (Chinery, 1995; Hussain *et al.,* 2009).

As a result, urban environments exhibit significant spatial variation in their development level. Well-developed city centres are often surrounded by under developed and inadequately serviced settlements supporting a large fraction of the population (Gardiner *et al*., 1984). To date, the African continent is considerably less urbanized when compared with the rest of the world (Keiser *et al*., 2006). For example, in the year 2001 urban dwellers in East Africa accounted for only 25% of the population, compared with 70% and above elsewhere in the world. Current estimates by the UN predict that half of the African population will live in urban settings by the year 2025, and that the percentage will further increase to 52.9% or 787 million in 2030 (UN, 2002) In contrast, the rural population will experience a slower growth: from 498millionin 2000(52.8%) to an expected 702 millionin2030 (47.1%) (Baragatti *et al.,* 2009).

There are two underlying reasons. First, there are strong rural-urban economically driven migrations with people seeking education and job opportunities outside subsistence farming. Second, rural settlements have evolved into small or medium size cities. In 1950, there was not one single megacity (define displaces with 750,000 inhabitants)onthe African continent. Fifty years later there were 43 megacities, already harboring 11.9% of the African population. It is estimated that in 2010 more than 100 cities on the African continent will have a population of at least 500,000, and more than half of them will be inhabited by more than one million people (UN, 2002).

VII. THE BURDEN OF MALARIA IN SUB SAHARAN AFRICA

Malaria threatens the lives of 40% of the world's population – over 2.2 billion people (UN,2000). Malaria continues to be the most significant mosquito-borne disease globally but it holds a particularly heavy burden across many countries in Africa where in 2015, 88% of global cases and 90% of global deaths due to malaria were recorded (WHO, 2016).The World Health Organization and the World Bank rank malaria as the largest single component of the disease burden in Africa, causing an annual loss of 35 million future life-years from disability and premature mortality (WHO, 2010). In Africa, malaria is responsible for about 20-30% of hospital admissions and about 30-50% of outpatient consultations (UN, 2000). Sub-Saharan Africa still remains the most malaria endemic area in the world (WHO, 2003). The global impact of malaria is staggering, regardless of how it is measured. The cost of malaria can be measured in lives lost, in time spent ill with fever, and in economic terms(Chima *et al*., 2003; Ukpong *et al*., 2007). Money spent on preventing and treating malaria, the indirect costs of lost wages, time home from school, and time spent caring for sick children, adds up at the personal level (Chima *et al.,* 2003).

In most countries in sub-Saharan Africa, in the public sector, large fractions of health sector budgets are spent on malaria control and treatment and at the macroeconomic level, a heavy national burden of malaria dampens economic development, sometimes subtly, but pervasively. All of these effects are recognized and accepted widely, but their magnitude has been poorly documented in areas where malaria is highly endemic, a protective semiimmunity against *P. falciparum* is acquired during the first 10–15 years of life, and the majority of malaria-related morbidity and mortality happen in young children (Riley *et al*., 1994). Thus, the impact of malaria on child health is enormous. However, in contrast with low malaria prevalence in adults, pregnant women in endemic areas are highly susceptible to malaria, and both the frequency and the severity of disease are higher in pregnant than non-pregnant women (Brabin, 1983).

Malaria during pregnancy is a serious problem in sub-Saharan Africa, affecting an estimated 24 million pregnant women (Steketee, 2001). Each year between 75,000 and 200,000 infant deaths are attributed to malaria infection in pregnancy globally (Steketee, 2001). Pregnancies in women living in malaria endemic regions particularly in subSaharan Africa are associated with a high frequency and density of *P. falciparum* parasitaemia, with high rates of maternal morbidity including fever and severe anaemia, with abortion and stillbirth, and with high rates of placental malaria and consequently low birth weight in newborns caused by both prematurity and intrauterine growth retardation (Bouvier *et al.,* 1997). Beyond mortality, malaria causes morbidity through fever, weakness, malnutrition, anemia, spleen diseases and vulnerability to other diseases. The health consequences of malaria vary in terms of severity, but the global impact of malaria on human health, productivity, and general wellbeing is profound particularly in sub-Saharan Africa (Snow, 2003)

Malaria imposes substantive social and economic costs and impedes economic development through several channels, including but certainly not limited to, quality of life, fertility, population growth, saving and investment, worker productivity, premature mortality and medical costs in subSaharan Africa (Snow,2003; Sach and Malaney, 2002). Malaria is estimated to cause a decline in economic growth,

overall life expectancy and geographic location (Guerin,2002;Sach and Malaney, 2002).

VIII. PUBLIC HEALTH CONSIDERATION

Malaria is a major threat to public health and economic development in Africa (Baragatti *et al*., 2009). It is a disease of poverty and underdevelopment and in sub-Saharan Africa malaria disproportionately affects the poorest of the poor populations including the forest communities which are often excluded from development processes (Hussain *et al.,* 2009). Reaching the poorest of the poor with malaria control interventions poses great challenges, not solely because of financial barriers to accessing care and prevention services but also because the poorest populations often live in the most remote areas and are socially or culturally marginalized (Martens *et al.,* 1995). With the fact that forests, almost by definition, have lower population densities than urban areas, people living in forest and rural areas under threat of deforestation tend to be disregarded in formal health care systems including systematic malaria interventions. In most parts of the sub-Saharan Africa, these areas are often difficult to reach, and remote forested areas may have difficulty attracting doctors, nurses and health system administrators. There are ethical and practical reasons for reversing this trend (Mars, 2010).

In the global development community, concerns that public health interventions may not be reaching poor and marginalized populations have led investigators to examine the differences in the burden of disease and the coverage and impact of public health interventions among persons with differing socioeconomic status (Degarege *et al.,* 2019) . If extra efforts are not made to reach the poorest of the poor with effective malaria control interventions, it is very likely that the Roll Back Malaria (RBM) target of reducing the global malaria burden by 50% by the year 2020 will not be reached particularly in sub-Saharan Africa. Interventions, therefore, must be designed to ensure that a large percentage of the most poor are using effective treatment, insecticide-treated bed nets (ITNs), and other essential malaria control interventions (Lengeler, 2004; Kilian *et al.,* 2016)

IX. URBANIZATION AND ITS' EFFECT ON PUBLIC HEALTH

Urban centres offer their residents greater possibility for health and social services. Different factors, such as education, direct primary care services, and the governments' capacity for rapid response to upcoming health threats, can contribute to the opportunities in a city. However, in many cities the poor can find it difficult to access proper health care, due to the cost of such services. In more rural areas, the problem can instead be the distance to the nearest clinic, which in reality makes it impossible for prompt and efficient treatment (WHO, 2010). Malaria has historically been and is still a major health concern in large parts of the world. WHO estimates 198 million cases (124-283 million) of malaria and 584,000 deaths (367,000-755,000) in 2013. The highest mortality rates have been shown to be closely linked to poor countries with a low gross national income (GNI) per capital (WHO, 2014). Estimations have been made that nearly 25% of the total African population, 200 million, currently live in urban settings where malaria transmission is a reality. The annual incidence is estimated at 24.8-103.2 million cases of clinical malaria among the urban population in Africa (Keiser *et al.,* 2004). The relationship between the malaria mosquito vector and the human host determines the burden of morbidity and mortality. This interface is dependent on many different factors and the degree of urbanization is an important one. A significant reduction in malaria transmission has been observed over the last century. Increased urbanization and decreased transmission have correlated in several different studies (Hay *et al*., 2005). However, whether it was the increased urbanization that led to areduction in transmission or the malaria reduction that led to development that promoted urbanization of societies is a challenge to determine (Tatem *et al*., 2013). A clear connection has been shown between reduced transmission of *Plasmodium falciparum* and urbanization; however, for *Plasmodium vivax* it is less obvious.

The overall decrease of the burden of malaria has been a positive effect of urbanization, but the exact mechanisms are not yet known. However, it seems that urbanization can have a favourable influence. Immunization status between residents inurban centres and rural areas can differ. Coverage of measles vaccination in Indonesia have shown to be 68.5% in rural areas, compared with 80.1% in urban regions (Fermandez *et al*., 2011). Studies in Nigeria have shown that sometimes the coverage can actually be better in more rural areas, and it might be explained by better mobilization and participation in the delivery of immunization services (Itimi *et al*., 2012). In a study in Uganda, 58% of the urban group compared to 53% in the rural areas were fully immunized, but polio vaccine was given to 51% in the urban group and 52% in the rural group (Bbaale *et al.,* 2013). Immunization coverage can also vary considerably among different settings, not only between rural and urban surroundings, but also between urban, rural, and slum settlements. A study in Tanzania has compared the knowledge about certain zoonotic diseases among general practitioners in urban and rural areas. The rural practitioners had poor knowledge of how sleeping sickness is transmitted and clinical features of anthrax and rabies. Laboratories in rural areas are often poorly equipped and cannot always diagnose certain zoonotic diseases, which could limit the doctors' capability for correct diagnosis and treatment (John *et al*., 2008). Public knowledge about certain infectious diseases can also vary depending on many different factors. The knowledge about sexually transmitted diseases (STIs) among Bangladeshi adolescents was higher among people in urban areas compared to rural, both in general and HIV and AIDS (Gani *et al.,* 2014).

X. MALARIA TRANSMISSION AND GLOBAL PUBLIC HEALTH

Natural transmission of malaria infection occurs by exposure to the bites of infective female anopheles mosquitoes (Dobson, 1999). The alternation between the human host and the mosquito vector represents the biological cycle of malaria transmission. *Plasmodium falciparum* is the most common and clinically serious of the four malaria parasite species that infect humans and is found throughout the tropics and subtropics (Snow *et al.,* 2002). Climate, particularly temperature and rainfall, affects the ability of malaria parasites and anophelene vectors to coexist long enough to enable transmission. The result is a diversity of *P. falciparum* exposure across the world and the African continent (Craig *et al.,* 1999; Rogers *et al.*, 2002). This diversity presents a great challenge to those attempting to define disease burden, as the distribution of the risk and its correlation with the location of the human population needs to be quantified objectively (Snow *et al.*, 1996). Despite reducing the extent of global malaria distribution by almost 50% during the twentieth century, approximately 3 billion people (almost half the global population) inhabit areas where there is a risk of acquiring malaria infection (Hay *et al.,* 2004).

The World Health Organization (WHO) estimates that each year there are between 300 million and 500 million clinical attacks of malaria globally, resulting in more than 1 million deaths (WHO,2003). It is also assumed that about 85% of these deaths occur in Africa, mostly in young children (WHO,2003). In Africa, malaria is the main cause of mortality in children less than five years old (20%) and constitutes 10% of the overall disease burden (WHO/UNICEF,2003). It is responsible for approximately 40% of public-health expenditure, 30–50% of inpatient admissions and up to 50% of outpatient visits in areas with high rates of malaria transmission (WHO/UNICEF, 2003). In addition to the morbidity and mortality that are directly attributed to *P. falciparum*, there are other consequential and indirect effects on mortality that are linked to each step of the infection and disease processes. Chronic, sub-clinical infections cause anaemia or can exacerbate undernutrition, which in turn can increase susceptibility to severe clinical outcomes of subsequent infection with *P. falciparum* or other pathogens. During pregnancy, asymptomatic infection of the placenta markedly reduces birth weights and infant survival rates. Patients who survive severe disease can be left with debilitating neurological sequelae (Omokanye *et al.,* 2012).

Malaria not only poses a risk to survival, but the repeated clinical consequences of infection during early life place a burden on individual households, the health service and, ultimately, the economic development of communities and nations (Rowe *et al.*, 2000). It has been argued that the persistence of endemic malaria in the tropics and sub-tropics significantly contributes to a perpetual state of depressed economic growth (Riley, 1994). This goal has been conceived at a time when existing, affordable therapeutics are failing,

health-service provision does not keep pace with population growth, there is no immediate prospect of widespread vaccination and poverty continues to afflict most countries where malaria is endemic. Despite these challenges, malaria is a preventable infection and a curable disease. Effective intervention strategies are aimed at increasing access to insecticide-treated nets and prompt effective treatment, as well as providing intermittent treatment to women during pregnancy and to atrisk infants regardless of disease status. International initiatives, such as RBM, require a sound evidence base on which to prioritize allocation of the limited resources that are available for therapeutic intervention. Improving our estimates of morbidity and mortality in Africa by increasing our understanding of the impact of urbanization can be considered part of this wider objective (Padilla *et al.*, 2015).

Contrary to common perception, the improved health status of urban populations compared with rural populations in Africa has been observed by many studies. For example, infant mortality rates and childhood mortality rates are lower in urban populations compared with rural populations. These same surveys show that, compared with those living in rural areas, mothers and children living in urban communities have better nutritional status indicators; fewer morbid events; increased vaccine coverage; better physical access to health services; and greater use of insecticide-treated nets (ITN) (Snow *et al.*,2003; Chaki *et al.,*2009).

XI. FACTORS AFFECTING MALARIA TRANSMISSION IN SUB- SAHARA AFRICA

Most sub-Saharan African countries are experiencing unprecedented rate of population growth without any appreciable improvement in the socio-economic status of the populace. The heavy burden of malaria in rural Africa is testimony to the ability of natural breeding sites to sustain vector populations. Natural breeding sites, although less common in urban areas, are nevertheless present.T here is therefore a high level of poverty and underdevelopment in the region particularly in the rural areas. One major consequence of this situation is uncontrolled and unsustainable exploitation of natural resources, especially the forests resources, which has generated severe environmental, ecological and public health problems including increase in vector-borne diseases like malaria (Padilla *et al.*, 2015).

Deforestation

Forests are among the world's most important biomes in terms of the area of land surface they cover (approximately 30% of all land - over 3.8 billion hectares (UN,2003)and the goods and services they provide, and the biodiversity they contain (approximately 90% of terrestrial biodiversity) (EFTEC, 2005). More than 1 billion people depend on forests for their livelihoods to varying degrees and 60 million indigenous people are almost wholly dependent on forests, while around 350 million people living within or adjacent to dense forests depend on them to a high degree for subsistence and income,

in developing countries, agro-forestry farming schemes support 1.2 billion people and help sustain agricultural productivity and the generation of income (Patz *et al.,* 2000). Forest industries provide employment for some 60 million people worldwide (EFTEC,2005).

Through the process of clearing, deforestation alters every element of local ecosystems such as microclimate, soil, and aquatic conditions, and most significantly, the ecology of local flora and fauna, including human disease vectors (Patz *et al.*, 2000). Of all the forest vector species that transmit diseases to humans, mosquitoes are among the most sensitive to environmental changes because of deforestation: their survival, density, and distribution are dramatically influenced by small changes in environmental conditions, such as temperature, humidity, and the availability of suitable breeding sites (Martens, 1998; Molyneux, 1998; Grillet, 2000). Changes in mosquito ecology and human behaviour patterns in deforested regions influence the transmission of mosquitoborne diseases such as malaria, Japanese encephalitis, and filariasis (Walsh *et al.*, 1993; Kondrashin *et al.,* 1991).

In particular, each incident of deforestation and land transformation has a different influence on the prevalence, incidence, and distribution of malaria directly and indirectly (Walsh *et al.*, 1993). Numerous country and area studies have described the influence of deforestation and subsequent land use on the density of local mosquito vectors. Some of the studies were able to follow-up further and observe changes in local malaria incidence and prevalence due to the mosquito density change (Walsh *et al.*, 1993; Patz *et al.,* 2000). Thus malaria transmission (and also the control) has clear links to ecosystem changes that result from natural resource policies such as land tenure, road building, and agricultural subsidies; and deforestation is a major development policy concern which often heralds many other 'malaria-causing' land use changes (Pattanaya *et al.*, 2006) .Despite the high rates of malaria and deforestation in sub-Saharan Africa, the relationships between both contextual challenges have not been comprehensively assessed (Meadows, 2008).

Altitude

Altitude is commonly thought to play an important role in limiting malaria in the tropical highlands by negatively influencing the development of vector species. In a study of malaria prevalence in south-western Uganda, altitudes higher than 1,500m were shown to be associated with low malaria risk (Bloland *et al.,* 1995); however, the presence of vector species at these altitudes cannot be ruled out since a study in the Kenyan highlands revealed high densities of *An. gambiae* mosquitoes in a town 1,650m above sea level and still more at altitudes higher than 2,000m (ter Kuile *et al.*, 2004).

Urban Agriculture

Over the last decade, urban agriculture has become commonplace in sub-Saharan Africa, expanding into the peripheral belts and centres of many towns and cities (Walsh *et al.*,1993). Its benefit is that it increases food security while combating malnutrition and poverty; however, it also provides optimal conditions for vector breeding, leading to a higher risk of malaria transmission in its vicinity (Ayisi *et al.,* 2003; Sachs *et al.,* 2002). Agricultural trenches create ideal breeding sites due to the formation of shallow water between seed beds and, in one study in Abidjan, Cote d'Ivoire, anopheline larvae were present in over half (WHO, 2004). In another study in Cote d'Ivoire, rice fields were found to have the highest likelihood of anopheline presence throughout both wet and dry seasons (Coluzzi, 1984). Other breeding sites include irrigation wells, noncemented wells, ditches for furrow systems, and human footprints (Anon, 2001; Mayaux *et al.*, 2005). Larger breeding sites are more productive as they are less likely tob edisturbed by irrigation. Higher mosquito densities naturally lead to elevated levels of malaria transmission for people who either work on or live near urban agricultural fields (Walsh *et al.*, 1993; Achard *et al.,* 2002). For example, in a study in Maputo City, Mozambique, malaria parasitaemia was found to be higher among those who worked in urban agricultural areas throughout the city, irrespective of other factors such as urban or periurban location (WHO,2001). Urban agriculture is often associated with socioeconomic advantages, such as piped water, refuse collection, a sewage system, and better education; however, data from Accra, Ghana, suggests that the increase in vector breeding sites is sufficient to counteract these beneficial effects in terms of malaria transmission (WHO, 2003). There are currently no known initiatives in place for controlling malaria associated with urban agriculture, and control here should be mindful of socioeconomic considerations.

Drains, Ditches, and Gutters

While agriculture provides the most productive urban vector breeding sites, drains and ditches may provide more common habitats. In a study in Dar Salaam, Tanzania, there were three times more anopheline-positive drains and ditches compared to agricultural breeding sites, and anopheline presence was much more likely in drains that were blocked (Greenwood *et al.*, 1989).Blockages are often due to poor sanitation and lead to reduced water flow and accumulation of stagnant water pools which areideal for mosquito breeding. Gutters provide a similar breeding site for mosquitoes in both the wet and dry seasons and were specifically noted by a recent study in Abeokuta, Nigeria (Riesco, 2008).

Tyre Tracks

Tyre tracks were the second most-cited artificial vector breeding site. In Malindi, Kenya, they accounted for as much as 29% of all water bodies that were positive for mosquitoes (Snow *et al.*, 2003). Tyre tracks are more common in areas of high socioeconomic status, which tend to house more vehicle owners while still having roads of sufficiently poor quality to lead to theformation of potholes, tyre tracks, and other artificial breeding sites.

Human Factors

Socio-Economic Status. Higher socioeconomic status is associated with a number of factors that lead to reduced malaria transmission, from piped water and better refuse collection to better education, higher exposure to TV and radio prevention campaigns, and increased ability to afford prevention methods and treatment (Guerra *et al*., 2006). These factors contribute to a better awareness of vector breeding sites, malaria transmission, and control among people of higher socioeconomic status. The higher socioeconomic status of urband well ersisa major factor contributing to their reduced risk of contract ingmalaria (UN,2006);within citiessocio-economic factors contribute to increased transmission in poorer areas with slum-like conditions, as seen in Libreville, Gabon (Janssen and Wery, 1987), and in the periurban areas of many cities.

Household Factors

Better-quality housing decreases the risk of malaria as it minimizes entry points for mosquitoes during the night. To illustrate this, a study in Gambia showed that houses with malaria-infected children are more likely to have mud walls, open eaves, and absentceilings than those with uninfected children (Kondrashin *et al.,* 1991). Floors comprised of earth bricks are also associated with lower malaria risk as inhabitants are more likely to sleep on raised beds to avoid ground moisture, in turn eluding bites from An. gambiae mosquitoes which search for blood close to the ground(Kondrashin *et al.,* 1991). . Interestingly, a study in Burkina Faso found that electricity use was associated with increased malaria risk, as the alternative of biomass fuel burning produces smoke that is thought to deter mosquitoes from entering houses (WHO, 2006); however, electricity use ibetter-quality housing ould presumably not show this trend.

Community Factors

Hygiene, sanitation, and waste collection are key determinants of malaria transmission which, while household responsibilities, have a community level effect on disease transmission. As an example, the more the households dispose of waste properly, the lower the risk of liquid waste collecting in pools of stagnant water and forming vector breeding sites. In Accra, Ghana, being connected to a toilet was found to be even more important than waste removal in reducing community malaria mortality (Hughes, 2001); however, toilets are also potential areas of mosquito activity, and septic tanks within communities are a potential source of vector breeding sites (Volkman *et al*., 2001).

Vector Factors

An.gambiae is demonstrating a worrying trend of adaptation to polluted waters in urban environments (Molineaux *et al*., 1980).In recent years, thespecies has been found breeding in highly polluted water sources in Cote d'Ivoire (Coluzzi, 1984) and Cameroon (Jones and Williams, 2004), and in water-filled domestic containers in Accra, Ghana (Jongwutiwes *et al.,*

2004). In Lagos, Nigeria, and Kisumu and Malindi, Kenya, *An. gambiae s.s.* larvae have been found in water sources with high concentrations of heavy metals such as iron, copper, and lead, and other contaminants such as human faeces and petrol (UN, 2008). *An. arabiensis*, although tolerant of turbidity, was less tolerant of these pollutants (Singh *et al.,* 2004),aswas *An.funestus* (Reiter *et al.,* 2001),suggesting that these species are less adapted to polluted water sources than *An. gambiae s.s.* These findings suggest that the pollution associated with urbanisation will not necessarily continueto reduce vector densities in African cities, and urban vector control will become increasingly relevant in years to come.

Furthermore, the widespread use of ITNs and IRS, combined with insecticide usage in agriculture, is posing a strong selective pressure on vector populations to develop insecticide resistance, suggesting that future IVM programs will need to rely on a wide range of vector control strategies (Molineaux *et al.,* 1980). The mutually beneficial relationship between *Culexquinque fasciatus*—a non-malaria vector—and *An. gambiae* can lead to elevated malaria vector densities in urban environments (Greenwood *et al.,* 1989). *Culex. quinquefasciatus* breeds very efficiently in artificial sites like drainage facilities and, once inhabiting these sites, creates an environment in which *An. gambiae* can also breed. How this happens is yet to be explored. In a study in Abeokuta, Nigeria, *An. gambiae* were discovered in gutters blocked by refuseand sewage,butonly afterthey had already been inhabited by *Culex species*(Riesco, 2008).

XII. DISCUSSION

A better understanding of the dynamic process of urbanization, including urban risk factors for health, might lead to the development of suitable health interventions and preventive measures for the rising number of urban inhabitants. Effective targeting of limited resources for malaria control should be driven by an appreciation of need and based on a credible understanding of risk. The lack of an evidence based platform to understand the comparative risks of infection and disease outcomes in relation to *P. falciparum* and urbanization in Africa has been partly addressed in this article. Urbanization is an ongoing process in the world at the moment, but the pace of the process is not universal. The developed countries, which have traditionally been thought of as high-income countries, are already urbanized, and it is in the developing world that the rapid rise is taking place. Infectious diseases still have a big impact on the global health, and urbanization is now altering the characteristics of these diseases. Living conditions in cities are overall better in urban environments compared to rural settings; better housing, sanitation, ventilation, and social services all play an important role in this improvement. Certain pathogens can, however, adapt to the different conditions and thus create a new challenge for both local governments and the global community.

The capacity for surveillance, control programs, prevention, and public knowledge programs is far better in cities than in

rural areas. It is here where the resources and political and financial power are gathered. But some countries do not have the resources and because these diseases can be of global concern, it is also the international community's responsibility to help and support with knowledge and resources. The rapid urbanization has also interfered in previously untouched ecosystems. These new settlements create new and closer encounters with wildlife, which can be a potential source of zoonotic diseases. These can be previously known or new pathogens, which make the shift from their animal host to generate infections in humans. Surveillance is of primary importance to monitor the burden of disease and will give both local authorities and the global community a chance for a quick response to public health threats.

An overview of urbanization trends in Africa and the epidemiology of malaria was reviewed by Keiser et al. 2004 were it was estimated that about 200 million urban dwellers are currently at risk of malaria. These people are concentrated on a total surface area of less than 500,000 km2, representing a maximum of 1.6% of the entire African continent. It was estimated by Keiser et al.2004 that 24.8–103.2 million clinical malaria episodes occur annually in urban settings that are endemic for malaria. The contribution of malaria to social hardship and heavy economic losses resulting from high health care expenditures and loss of work productivity are increasingly acknowledged (Sachs and Malaney, 2002). This review also shows that the epidemiology of malaria in the urban areas is not fully comparable to what is well established for rural settings. For example, urban malaria is characterized by much greater heterogeneity, owing to the dynamic demographic and environmental conditions. Consequently, understanding the spatial and temporal pattern of urban malaria risk will facilitate the design of well-tailored integrated urban malaria control programs. There is a large body of historical evidence about great achievements of integrated malaria control in urban areas, predating by several decades the advent and large-scale application of DDT. Control measures were largely targeted at the larval stages of malaria vectors by means of source reduction. Application of oil and larvicides on open water bodies often complemented environmental control interventions

Careful planning in the design and implementation of interventions is paramount since environmental risk factors and malaria transmission depend upon locality. Furthermore, a sound knowledge base of the bionomics of the key malaria vectors and ongoing monitoring of breeding sites and their changes over time is of pressing necessity for the implementation of readily adapted environmental management interventions. Disease risk mapping produced with high spatial resolution imagery can provide an initial basis for identifying and analyzing the determinants of malaria risk, which has been demonstrated in an urban malaria control program in Dares Salaam between1988 and 1996 (Caldas et al., 2004). Pursuing this approach will also ensure that particular attention is paid to highly vulnerable and most disadvantaged urban environments, where the risk of disease-associated morbidity and mortality is highest, and where people are in most need.

Reviews suggests that lack of education, low income, poorly constructed houses, and farming are associated with an increased prevalence/incidence of *Plasmodium* infection in SSA. In addition, this review showed a decreased linear trend of *Plasmodium* infection with an increase in the wealth index, which was measured based on household assets ownership, quality of the house, education and occupation. A previous review by Tusting *et al*. (2013),also reported lower odds of *Plasmodium* infection among children who belong to households with low SES group as compared to those who belong to high SES households. However, unlike the current study which examined the linear trend of decrease in *Plasmodium* infection with an increase in the wealth index/socioeconomic group (continuous or categorical) in different population group, the meta-analysis by Tusting *et al.* (2013) limited the comparison to children in the least poor (richest) and poorest socioeconomic groups. In agreement with the current finding, another review by Tusting *et al*. (2015) also showed an increased odds of *Plasmodium* infection among individuals living in houses with mud walls, thatch roof, unscreened window, open eaves and lack of ceilings (Tusting *et al.,* 2015). The observed association between socioeconomic indicators and *Plasmodium* infection could be due to the effect of SES factors on access and behaviours towards malaria diagnosis, treatment, and prevention measures in SSA. SES indicators may affect behaviour and practice of individuals to prevent malaria differently. Education is linked to productivity, capital or potential earning, occupational opportunity, and socialization of individuals. Education also increases knowledge, skills, and ability of the individual to access information that promotes health (Mmbando *et al.,* 2008).

Knowledge could lead to a better acceptance and practice of malaria prevention measures. Higher income also provides better housing, schooling, and nutrition that could enhance malaria prevention. Similarly, income level determines the capacity of individuals to buy malaria preventive measures such as insecticide treated nets (ITNs) and indoor residual sprays. Occupation may affect income level, in turn affecting access to malaria preventive measures. Indeed, different studies in SSA have shown an association of mosquito bed net ownership and use with wealth (Macintyre *et al*., 2002; Njama *et al*., 2003;Bernard *et al*., 2009), occupation(Macintyre *et al*., 2002; Noor *et al.,* 2006), and educational status (Goesch *et al*., 2008). Another study in Sudan showed an improved use of malaria prevention strategies such as ITNs and house spraying with an increase in household wealth (Onwujekwe *et al*., 2006). SES may also affect individuals' ability to get diagnosed and treated for malaria. Educational status could affect the ability to understand written or verbal information about symptoms, treatment, and transmission mechanisms of malaria. This literacy in turn could affect the practice of individuals to get treated for malaria. Financial resources could also affect individuals' capability to use available goods

and services to treat malaria. For example, the poorest people may not have sufficient money to cover transportation, consultation with healthcare providers, and payment for drugs when they are ill. As a result, people may not seek care. A study in Tanzania found an increased chance of receiving antimalarial drugs in children who had wealthier families compared to poorer families (Schellenberg et al., 2003). Some SES indicators may also directly affect the occurrence of malaria.

Most malaria transmission in Africa occurs due to mosquitoes resting indoors (Huho *et al.,* 2013). The quality of the house thus determines successful entrance of mosquitoes into the house. A house could be constructed without windows or screens, thus exposing individuals to malaria vectors (Linsay *et al.,* 2003). A study in Gambia found an increased number of indoor residual mosquito vectors in houses made with mud blocks compared to those with concrete ones (Kirby *et al.,* 2003). The effect of occupation on malaria incidence can also be direct. Some occupations like agriculture may increase contact of individuals with mosquito vectors, increasing the risk of Plasmodium infection. In addition, when working in forested areas and migratory activities in the highland fringes, individuals will have less access to healthcare facilities, increasing the risk of Plasmodium infection (Ghebreyesus *et al.,* 2000).

XIII. CONCLUSION

Lack of education, low income, low wealth, living in poorly constructed houses, and having an occupation in farming may increase risk of *Plasmodium* infection among people in SSA. Public policy measures that can reduce inequity in health coverage, as well as improve economic and educational opportunities for the poor, will help in reducing the burden of malaria in SSA.Studies have concluded that anopheline speciesdensity and the likelihood of malaria transmission are lower in urban than rural areas. This likelihood of low transmission is stronger in central urban areas compared with periurban areas. The impact of urbanization on transmission is as marked as the mean rainfall is low and seasonal. In summary, it can be concluded that the dual effects of behavioural changes and transmission reduction that are associated with urbanization make for profound decreases in morbidity and mortality from malaria in Africa. The construction of global maps of urban extents provides scientists and policy makers with new opportunities to quantify and perhaps predict the coincidental transitions in population and disease in low-income nations over time

Thus, there is a need for a rigorous and systematic approach to characterize malaria transmission in the rural-to-urban interface that could provide solid information to assess disease risk in such contexts.

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