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PUBLIC HEALTH CHALLENGES
WITH SUB-SAHARAN AFRICAN
INFORMAL SETTLEMENTS

A Case Study of Malaria in Yaoundé

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Introduction
Despite the rise of non-communicable diseases in urban Sub-Saharan Africa (SSA), communicable diseases still have a significant burden on populations’ health and countries’ development. A rapid urbanization is being experienced in Africa, with the urban population projected to grow from 36% in 2010 to 50% by 2030. Up to 60% of urban population in Africa is estimated to be living in informal settlements or informal settlement-like conditions. Literature on population health status in urban informal settlements is scanty in Africa. The aim of this chapter is to contribute to the knowledge of population health status in the informal settlements. It focuses on urban malaria in the informal settlements of Yaoundé in Cameroon. Yaoundé is taken as a case study of a fast growing SSA medium sized city where demographic, environmental, social and entomological factors are drawing a pattern of urban malaria transmission that may be happening in many SSA cities of medium size. The chapter first underlines specific demographic trends of, and geographic insights into, informal settlements in SSA. It then briefly describes some innovative methods allowing the location and description of the socioeconomic, environmental and malarial profile of informal settlements in Yaoundé, using remote sensing and geographic tools. The chapter next presents core results of informal settlements’ population exposure to malaria determinants, and then discusses some of the lessons learned from the Yaoundé study on malaria in informal settlements, specifically in terms of weight of sociocultural factors, prevention efficiency and political barriers to better population health status in informal settlements. It also underlines the necessity to develop and implement cost effective methods, notably using geographic tools, to allow better monitoring and assessment of malaria and other diseases.

Malaria in Informal Settlements in Sub-Saharan Africa: Demographic Trends and Geographic Insights

A Demographic Challenge
According to the United Nations Human Settlements Programme (UN-Habitat), informal settlements are urban areas with a lack of basic services, substandard housing, overcrowding, unhealthy and hazardous locations, insecure tenure and social exclusion (UN-Habitat 2006). Nearly 1 billion people live in informal settlements, and this number is projected to double to 2 billion in the next
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30 years (UN-Habitat 2004). The unprecedented urbanization process of SSA is characterized by a massive increase of informal settlements’ population. Informal settlements now dominate many cities in low-income and middle-income countries (LMICs), and are increasing in total population size, especially in Africa (Ezeh et al. 2017) (Figures 36.1 and 36.2). For Central Africa, an increase in the urban informal settlement population by major areas can be observed until 2014, with variations throughout the time (Figure 36.1). This informal settlement population is now estimated to be the lowest of all SSA regions (Figure 36.1). Those numbers are driven by the informal settlement population in the Democratic Republic of Congo, followed by Cameroon and Angola (Figure 36.1). For West Africa, an increase was observed until 2010 (Figure 36.1). Numbers in West Africa are driven by Nigeria (Figure 36.2). An increase in the informal settlement population estimates was noted for East Africa, and the level is now higher than in South, West and Central Africa (Figure 36.1). Those numbers are driven by Ethiopia, followed by Kenya (Figure 36.2). A slight decrease can be noted for the level of estimated populations in informal settlements of the Southern African region, but this level is still higher than in Central Africa. The increase in informal settlements’ population comes with public health challenges for both non-communicable and infectious diseases.

A Variety of Sizes and Locations

Informal settlements are of different sizes and show different patterns in their geographic locations. Some informal settlements are located in peripheral areas of cities, while others are found in the urban core next to the business districts. Usually, cities’ spatial extension has a central origin, which complies with the von Thünen model (von Thünen 1850; Ngom 2010), with the exception that sometimes land values in most of the centrally located informal settlements are drastically reduced by local negative environmental characteristics. That expansion of the cities also has different ecological

![Figure 36.1 Urban slum population by major areas for defined regions in Africa.](image)

*Source:* Data from UN-Habitat (2014).
meanings, which will vary according to the ecological biome to which the city belongs. A city’s expansion in the Sahel will not have the same meaning as the expansion of a city in an equatorial tropical forest. Those ecological conditions are rendered more complex by the locations of informal settlements at the periphery or core area of the city. This geographic and ecological variability results in a variety of ecological conditions at a more granular level, such as neighborhoods within slums. Those differences impact on the type, periods and intensity of potential infectious diseases.

Infectious Diseases and Malaria in SSA’s Informal Settlements: What Do We Know?

Just like the incomplete urbanization process as compared to urbanization in industrialized Western countries, the epidemiological transition in SSA is incomplete. Non-communicable diseases now
outweigh communicable diseases as a cause of loss of life years even in LMICs (Ezeh et al. 2017). However, communicable diseases still have a substantial burden in SSA. As an example, the number of new malaria cases per 1,000 population at risk is 268.6 for the African region (WHO 2016). Despite progress made in the reduction of malaria prevalence, 90% of deaths are still caused by malaria in Africa. For this reason, malaria remains a priority in the Sustainable Development Goals (SDGs) (United Nations 2015).

The probability of dying from any of cardiovascular disease (CVD), cancer, diabetes, and chronic respiratory disease (CRD) between age 30 and exact age is 20.7% for the African region, while it is 24% for the East Asia region (WHO 2016). Ezeh et al. (2017) stated that rates for hypertension were slightly lower in informal settlements than in other populations in both Kenyan and Brazilian populations. The truth is that the non-communicable diseases risk in people who live in informal settlements is poorly documented. Only two reviews have examined non-communicable diseases in informal settlements, and both focused on the high prevalence of childhood asthma (McMichael 2000; Ezeh et al. 2017).

The existing documentation on infectious diseases in informal settlements shows that children are particularly vulnerable. Child health indicators are worse in the informal settlements than in poor rural areas within the same country (Ezeh et al. 2017). In general, children’s health in informal settlements is worse than the health of other urban populations (Ramin 2009). Given the concurrent population exposure to communicable and non-communicable diseases, one of the biggest challenges here is to understand how demographic factors and the rapid urbanization process, combined with socioeconomic status, are impacting population health status in SSA cities.

Health, environmental and social indicators are in favor of the persistent presence of infectious diseases in SSA. Populations in informal settlements probably represent a large part of that burden. In addition, the fourth assessment report of the Intergovernmental Panel on Climate Change states that “urbanization and climate change may work synergistically to increase disease burdens” (Confalonieri et al. 2007). Climate change may be a major trigger for in-migration to urban areas, further stressing urban infrastructure (Ramin 2009). Malaria specifically has been highlighted in climate change health impact models, and has been qualified as one of the diseases with a very high confidence in the predictions. Expansions and contractions have been predicted for malaria, as well as changes in transmission seasons (McMichael et al. 2003; Confalonieri et al. 2007). However, local transmission dynamics related to demographic and socioeconomic conditions are of crucial importance in understanding the present and future trends in malaria prevalence (Ngom and Siegmund 2015). Political instability and corruption may also affect malaria prevalence among a large part of SSA populations, including in informal settlements.

**Malaria in the Informal Settlements of Yaoundé**

*Collecting and Measuring Malaria Prevalence and Related Factors in Yaoundé’s Informal Settlements*

Yaoundé, the capital city of Cameroon, a country located in Central Africa, has an estimated population of 2.44 million inhabitants (Cameroon National Institute of Statistics 2011). Like many SSA cities of medium size, Yaoundé is experiencing a rapid urbanization process. The urbanization rate is currently estimated at 6.8% (Rotich et al. 2006) for Yaoundé against 3.3% for the whole country; 58% of the country is urbanized, and that percentage continues to grow annually (World Bank 2018). Our personal inquiries estimate that 49% of the city’s population is living in informal settlements (Ngom 2010). The city belongs to a holoendemic malaria zone, and shows an overlap of rural and urban settings.
Obtaining data for usage in scientific analyses is difficult not only for informal settlements but also for entire SSA cities. For the purpose of comparing informal settlements to other parts of the city of Yaoundé, a stratified random sampling was implemented. The entire city of Yaoundé was stratified into squares of equal dimensions, and households were randomly selected from these squares for the administering of a retrospective questionnaire on malaria clinical and febrile episodes (calendar year 2006) and related socioeconomic and environmental factors. A total of 1,925 households with approximately 10,000 individuals were reached by the end of the study. After the removal of all biases, a total of 1,408 households including 8,974 individuals were surveyed and used for analyses. This study was reviewed and approved by the institutional review board at the University of Education of Heidelberg in Germany. High spatial resolution remote sensing data (QuickBird 2.4 meters) were used to obtain the distribution of the spatial densities of buildings in various settings of the entire city. It was possible to classify various clusters of houses’ densities (variation based on buildings’ densities), and to identify those that were likely to represent informal settlements using field collected socioeconomic factors (Figure 36.3). The same remote sensing data were used to identify and map water bodies and agricultural fields within the city (Ngom 2010; Ngom and Siegmund 2010, 2015).

Socioeconomic factors considered included employment, households’ expenditures, prevention behavior, and room crowding (population density in rooms). Environmental variables included housing quality (modern housing standard or not), proximity to agricultural fields, water bodies, presence of wells in the neighborhood and topography. In order to perform a statistical evaluation of the relationship between malaria prevalence and the various social and environmental factors, multivariate models were developed for each of the clusters.

**Higher Malaria Prevalence in Rural-Like Areas and Informal Settlements**

In the case of Yaoundé, informal settlement-like clusters had a central geographic location within the city. They were located next to the business districts’ centers. They represented half (49%) of the city’s total population (Ngom and Siegmund 2015). They showed profiles of low socioeconomic status (SES). However, numbers did not show a 100% homogeneous distribution of those SES variables. Those informal settlement-like clusters covered the districts of la Briqueterie, Elig-Edzoa, Mvog Ada, Nkolndongo, Kondengui, Nkomo and Etam Bafia. The second densest cluster was located in the central planned residential districts of Essos Nord, Elig-Essono, Centre administrative,
Nkolbong (popular name Bastos) and also the more recently built, planned residential areas of Biyem-Assi Maetur, Obobogo, Mballa 3 and Mballa. The rural-like clusters were located in the districts of Anguissa Metui, Awae, Ekie, Ndamvout, Messame Ndongo and Odza in the suburbs of the city. Mimboman and Nkolmesseng districts also showed low-density clusters, despite their higher proximity to the central business districts, compared to rural-like districts (Figure 36.4).

There were some similarities between informal settlement-like clusters and rural-like clusters located in the suburbs of the city. Typically, they both showed the highest percentage of dwellings with outhouse toilets (42% and 52% respectively for informal settlement-like and rural-like clusters), the highest number of people involved in the informal economy (36% and 25% respectively for informal settlement-like and rural-like clusters), the lowest proportion of people involved in professional occupations such as lawyers, notaries and bailiffs (2.45% and 3.28% respectively for informal settlement-like and rural-like clusters), the highest proportion of households with expenditures lower than or equal to $52 per month (32% and 15% respectively for informal settlement-like and rural-like clusters), and the highest proportion of houses having visible gaps in walls (21%).

However, informal settlement-like clusters were located at a farther distance from agricultural areas (0.69 kilometers on average) compared to rural-like clusters, which were closer to the agricultural fields (0.48 kilometers on average). Informal settlement-like clusters had a higher percentage of houses with no ceiling (81%), the highest percentage of houses made of *poto poto* (the local name for clay) (28%), the highest presence of wells in the neighborhood (39%), the lowest proportion of individuals under insecticide-treated nets (ITNs) (11% against 15% for the rural-like clusters), the lowest percentage of indoor residual sprays (IRSs) (19% against 25% for the rural-like clusters), the second highest drug intake frequency for prevention purposes, and the lowest percentage of house neighborhoods declared to be frequently cleaned (15% against 44% for the rural-like clusters). Another important
factor describing the informal settlement-like clusters was the lowest slope values, which testifies that they are mainly located in valleys, probably flood zones.

Malaria relative risk showed a monotonically increasing value from the second densest cluster after the informal settlement-like clusters to the rural-like clusters (Figure 36.5, A). Thus, the lowest risk was observed in the least rural, less informal settlement-like and most well-planned areas. Many of those areas corresponded to what is called social housing in Cameroon, extended constructed zones having similar architecture, planned and developed by the government (Figure 36.5, B).

**Figure 36.5** Distribution of factors relevant for malaria infection in slum-like clusters and rural-like clusters. **Source:** Roland Ngom.
People living in high-quality houses in informal settlement-like clusters (Figure 36.5, B and C) were at lower risk of malaria (odds ratio = 0.50; confidence intervals = 0.39–0.66; p < 0.001). Poor-quality housing, particularly houses with walls made of laterite and with outhouse toilets (Figure 36.6, A), rendered individuals particularly vulnerable to malaria in those clusters. Those factors were significant only in the informal settlement-like clusters (odds ratio = 1.07; confidence intervals = 1.02–1.13; p < 0.01).

The second most important predictive variable in the models was the proximity to urban agricultural fields (Figure 36.5, D and Figure 36.6, C and D). The variable describing the distance to agricultural fields showed an odds ratio of 0.64 and a confidence interval of 0.55–0.74, with p < 0.001.

In informal settlement-like clusters, individuals living in houses with walls made of laterite and outhouse toilets were significantly closer to cultivated areas than the others (Figure 36.5, C and D). Also, wealthier individuals (i.e., highest monthly expenditures) were living at significantly farther distances from cultivated areas than poor individuals in informal settlement-like clusters (Ngom and Siegmund 2015).

Despite the fact that populations in the rural-like clusters were more frequently using preventive methods than those in informal settlement-like clusters (Figure 36.5, E and F), prevention appeared to be more efficient in informal settlement-like clusters, particularly the utilization of IRSs and ITNs (odds ratio = 0.89; confidence intervals = 0.85–0.94; p < 0.001). Drug intake and regular cleaning of...
the area surrounding the house were also a significant variable in the informal settlement-like clusters model (odds ratio = 0.92; confidence intervals = 0.88–0.97; p < 0.01). This may be explained by the better access to those products, i.e., a shorter distance to the markets and the higher possibility of renewing the products more frequently. However, it is important to note that the utilization of preventive methods was significantly associated with a higher SES in all the clusters, except for rural-like clusters. Sleeping room density and slopes (Figure 36.5, G and H) were also significant but less important factors in informal settlement-like clusters (sleeping room density: odds ratio = 0.99; confidence intervals = 0.99–0.99; p < 0.001; slopes: odds ratio = 1.03; confidence intervals = 1.01–1.04).

What Lessons Can We Learn from the Example of Yaoundé?

The Weight of the Rural–Urban Cultural Transfer

Every urbanization process is characterized by the transformation of a place from a rural-like setting to one with urban characteristics. In some places, this process is never completely realized. This results in the permanent presence of rural-like characteristics within cities, specifically in informal settlements. As in informal settlements in Yaoundé, this is particularly true for informal settlements in SSA cities. Those rural-like characteristics of the SSA informal settlements are reinforced by population displacements from villages to cities. In the case of Yaoundé, it is estimated that the autochthonous represent only 20% of the informal settlements’ total population (Nguegang Asaa 2008). This overlapping of rural and urban patterns has an impact on the health of the informal settlement populations.

The example of Yaoundé demonstrates the way the urbanization process is happening in SSA countries, and how, despite a rise in non-communicable diseases, communicable diseases still remain a significant problem. When considering population densities, informal settlements are definitively part of the definition of an urban area. However, many similarities between informal settlements and rural settings render the process more complex. Rural features in terms of housing types and architecture (outhouse toilets) as well as agricultural activities play a central role in the spread of malaria within informal settlements, including other vector borne diseases, as shown in Yaoundé. Such an environment offers a breeding ground for vectors. Those conclusions are consistent with the findings of several authors who identified the role of housing material in malaria transmission (Betsi et al. 2003; Briet et al. 2003; Koudou et al. 2005; De Silva and Marshall 2012; Guerra et al. 2018; van den Berg et al. 2018).

Regarding its economic and environmental as well as nutritional and health contribution, urban agriculture is a sensitive activity. In Yaoundé, extensive commercial agricultural activities motivated by high profitability are practiced within and around informal settlements. The profitability of commercial urban agricultural activities is dependent on the proximity of millions of consumers, a number that is expected to grow in the near future. Agriculture in the peri-urban, rural-like areas is primarily practiced for domestic purposes by the autochthonous (Nguegang Asaa 2008; Ngom and Siegmund 2015). Since the major malaria vector An. Gambiae prefers non-perturbed areas that are different to informal settlements, it is hypothesized that agricultural areas are the main malaria vector providers, as shown in Ethiopia (Maledé et al. 2018).

In addition, entomological studies conducted in Yaoundé suggest a higher resistance to insecticides in cultivated areas (Antonio-Nkondjio et al. 2011) and the adaptation of the M molecular form of An. gambiae to highly perturbed, dense and polluted urban areas (Kamdem et al. 2012). This adaptation of vectors might change the transmission pattern of malaria in informal settlements in the future, rendering populations in informal settlements more vulnerable. In addition, given the important role of SES factors in malaria transmission, the ongoing gentrification phenomenon in rural-like
peripheral areas might actually confine malaria presence in informal settlements in the future (Ngom and Siegmund 2015). Gentrification is likely to happen in several other cities in SSA with similar consequences on populations' health.

**Disease Prevention Is Possible in Informal Settlements and Can Be Achieved**

Results of the study of urban malaria in Yaoundé also show that prevention is the most effective and realistic way to avoid malaria in informal settlements. They demonstrate that several ongoing programs consisting of the distribution of ITNs are actually beneficial to populations living in informal settlements and should be maintained and focused to informal settlements’ populations as well as poor populations living in rural-like peripheral areas for a sense of health equity. Compared to rural-like peripheral areas, populations in informal settlements are clearly advantaged, since they have better access to malaria prevention methods. As reported in Accra, Ghana, the urban poor seem to have a sense of willingness to support malaria intervention programs (Atiglo et al. 2018). Given the role of housing architecture, specifically the role of outhouse toilets, prevention methods should also focus on educational campaigns (health education/health promotion) pertaining to the relationships between people's behavior and exposure to vectors’ activities (when, where and why vectors are more active). This approach requires considering local sociocultural practices and resources to support educational campaigns (Ngom 2010). Not disregarding the importance of prevention campaigns for malaria prevalence in informal settlements, it appears that the most important preventative element for consideration is the reduction of social exclusion, starting with effective city planning that accounts for the change in the informal settlements’ housing conditions and neighborhood. In most of the SSA urban areas, this sounds like a non-realistic perspective, given multiple failures in that direction. In many instances, those failures are objectively attributable to the corruption of the governments and political establishments.

**Political Commitment Is Key to Reducing Social Exclusion Which Is a Reality in the Informal Settlements**

There is a long and unfortunate history of more than 100 years in which people in informal settlements have been marginalized and even stigmatized, with the result that they have experienced and are still experiencing denial of access to basic services (Ezeh et al. 2017). Findings of an experimental study in the USA showed that providing vouchers so that people could move to a better-off neighborhood dramatically improved health, and young children’s prospects in the long term (Chetty et al. 2016; Ezeh et al. 2017). The presence of informal settlements in SSA cities is probably imputable to a normal transitional process of postcolonial societies. This process might require a longer time to become less chaotic and to advance towards a more socially just system. However, it should be stressed that the presence of informal settlements is largely imputable to corruption and political failures at all levels, including at the very micro-level of the informal settlements themselves.

In the case of Yaoundé, results of the second densest clusters, which include planned areas locally called “social housing” that share the same standards as modern housing, show that the prevalence of communicable diseases, including but not limited to malaria, would be drastically reduced if real social housing that targets those living in informal settlements was applied. Unfortunately for the case of Cameroon, the so-called social houses are so expensive that they are not affordable even for some middle class workers. In addition, there is a system of corruption that allocates the houses to the wealthy members of the government and their relatives, and introduces real estate speculation in the social housing stock. Since it has been demonstrated that the level of malaria presence was
specifically reduced by the improved quality of housing, it is important to understand that governance, including corruption, affects the presence of malaria and other communicable diseases in cities, specifically in informal settlements. This process is clearly not aligning with the recommendations of the Lancet Commission on healthy cities in China, and specifically to pay more attention to health inequalities in promoting urban health (Rydin et al. 2012).

The complexity of urban malaria transmission patterns reveals the transversal character of the solutions to be implemented, including real political incentives in terms of subventions for social housing (Ngom 2010). It is a challenge to envisage a complete redevelopment of informal settlements in SSA cities. This redevelopment process may be more difficult to realize for populated cities with bigger informal settlements, as compared to medium-size cities such as Yaoundé. Examples of affordable housing programs such as those in South Africa have shown their limits, particularly their failure to satisfy the populations in need (Fieuw and Mitlin 2018). Improving housing conditions would be a solution to health problems in informal settlements, but implementing such solutions directly depends on the quality and level of political commitment and the ability of concerned populations to demand and influence changes, including at the local level.

**Geography and Geographic Tools Can Contribute to a Better Assessment of Health Status in SSA Informal Settlements**

There are many omissions and difficulties in the assessment of informal settlements’ population health in SSA (Ezeh et al. 2017; Lilford et al. 2017). Informal settlements’ exclusion and stigmatization also contribute to the inability to monitor and efficiently study those areas. In general, there are difficulties in collecting reliable socioeconomic, demographic and health data in SSA urban areas. There are technical difficulties in the enumeration of informal settlements’ populations (Hachmann et al. 2018): they are a hard to reach group because household members are often absent; people rent rooms only for the night; illegal squatters can avoid surveys; census staff can be afraid to enter informal settlements; and some countries do not have a census or have one only infrequently (Ezeh et al. 2017).

There is advocacy for the development of capacity for research into informal settlement health and the emergence of this as an academic specialty. It has been proposed that informal settlement health should be distinguished from urban health and mainstreamed in the implementation of the Sustainable Development Goals and the New Urban Agenda (Ezeh et al. 2017). A panel suggested processes to identify informal settlements for inclusion in censuses so that studies based on a census sampling frame can distinguish between informal settlement and non-informal settlement locations (Lilford et al. 2017).

The methods developed for the study of malaria in Yaoundé show that geography and geographic tools such as remote sensing allow cost effective monitoring of informal settlements within SSA cities. Using a survey and previously described spatial methods, it has been possible to demonstrate that monitoring the demographic expansion and population clustering of the city of Yaoundé (Ngom 2010), as well as understanding the global insertion of informal settlements within the city, including their population size (Ngom 2010), was feasible. It was also possible to describe neighborhoods’ environmental conditions, as exemplified by urban agriculture. Those environmental conditions are actively contributing to many communicable diseases in the informal settlements.

**Conclusion**

The study of malaria in Yaoundé’s informal settlements shows the relevance of sociocultural indicators of rural origins which result from an unfinished transformation process from rural to urban areas and socioeconomic exclusion. The type, material and architecture of houses and exposure to
urban agricultural fields are the main factors rendering informal settlement populations vulnerable to malaria and other related health challenges. The housing factor reveals the failure of planning and social housing policies—promoted, in part, by corrupt political systems—while urban agriculture can be seen as a way to cope with economic hardships resulting from unemployment, which in turn leads to health changes in the informal settlements. Insecticide resistance of malaria vectors in agricultural fields and adaptation of *An. gambiae* to perturbed areas such as informal settlements, combined with the ongoing gentrification phenomenon in rural-like areas situated in the suburbs of the city, might lead to the confinement of malaria in informal settlements in the future. However, on a positive note, malaria prevention is more effective in informal settlements than in rural-like areas of the city, specifically for the least deprived, and thus a critical need is to promote prevention of malaria in the informal settlements. For the population highly exposed to poor housing architecture and quality, innovative antimalarial campaigns based on health education approaches using local sociocultural indicators and resources should be implemented. There are numerous challenges for SSA cities in meeting the SDG goals on health and sustainable cities (SDGs 3 and 11). The ability to make progress within this agenda will largely depend on the level of attention paid to the informal settlements, since they contribute a large share of Africa’s urban population.

**References**


