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Impact of urbanization on the burden of infectious and non-communicable diseases in urban communities in Africa and South Asia

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By

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Ohio Wesleyan University
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Abstract

Impact of urbanization on the burden of infectious and non-communicable diseases in urban communities in Africa and South Asia

By Morgan N. Schroeder

Urban growth in the developing world is occurring at an unprecedented rate and magnitude; consequently many cities are stretched beyond their capacity to provide basic services to their citizens. People are drawn from rural settings to cities seeking opportunities, greater access to resources, and hope for a better future, but realization of these dreams is achieved by very few.. Of the 3.3 billion people living in urban areas worldwide, more than one billion people live in slums, including 56% of South Asians and 70% of sub-Saharan Africans. The nature of informal settlements exposes the urban poor to a profound number of disease factors for disease, but data are limited on the extent of the problem among urban slum populations, which hinders evidence-based action and interventions. This review examines the current and projected burdens of infectious and non-communicable disease in urban slums attributable to urbanization-related factors such as poor infrastructure, overcrowding, and lifestyle changes in African and South Asian countries, and identifies gaps and limitations of current knowledge about their prevalence and risk factors. Research in the future should include the collection of standardized, disaggregated urban health data to inform evidence-based action, engagement of the community and formation of multi-sectoral partnerships, and the enactment of innovative policies and programs that challenge underlying social norms that perpetuate the existence of urban slums, ultimately transforming the impact of urbanization from negative to positive.

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Chapter 1: Introduction

The world's human population has experienced historic, accelerated growth, particularly during the past fifty years with substantial implications on quality of life and health, and on the future of the planet. In 1800, only 3% of the world's population (then approximately 1 billion people) lived in urban areas; by the 1900s, the proportion reached 14% and urban growth was seen in virtually every region except Africa (Godfrey and Julien, 2005). Yet in the past 5 years, the world population crossed the 7 billion mark and the proportion of citizens living in urban areas surpassed 50%— the rate of growth in Africa is now twice as high as the global average and its population, is projected to double (principally in urban areas) by 2030 (State of the World Population, 2007). The phenomenon of "urban transition," is considered by many to be one of the most important issues facing public health in the 21st century (Hidden Cities, 2010).

Urbanization is defined by the United Nations Human Settlements Programme (UN-HABITAT) as "the process of transition from a rural to a more urban society" (State of the World Population, 2007). People have repeatedly been drawn from rural settings to cities seeking opportunities, greater access to resources, and hope for a better future, but realization of these dreams is not equally achieved by all. This is especially true in the developing world: of the 3.3 billion people living in urban areas worldwide, more than one billion people live in slums, including between 56% of South Asians and 70% of sub-Saharan Africans. Ninety percent of all slum dwellers reside in developing countries (State of the World Population, 2007; Patel and Burke, 2009; van de Vijver, Akinyi, Oti, Olajide, Agyemang, Aboderin, & Kyobutungi, 2013).

Moving to an urban setting involves new risk factors for disease due to swelling population densities, environmental contamination, and lifestyle changes, yet reliable urban

health statistics can be difficult to find and are rarely collected and disseminated to facilitate timely public health action (Leon, 2008). The objective of this review is to examine what is known about the past and current trajectory of urbanization, to characterize the current and projected burdens of disease attributable to massive rates of urbanization in African and South Asian countries, and to discuss the interventions, policies, and next steps that have and should be implemented to improve the lives of a vulnerable and marginalized population of slum dwellers.

1.1 Background and significance

The Industrial Revolution and the "first wave" of urbanization. Between the mid-18th century and 1950, Europe and the United States saw its proportion of urban dwellers swell from 15 million people to 423 million people, increasing from 10% of all citizens to more than 50% (Godfrey and Julien, 2005). The momentous London cholera outbreak of the 1840s that prompted John Snow's classic epidemiological studies originated from the woes of urbanization and the formation of slum conditions marked by virtually non-existent sanitation. Numerous sources of literature during this time period from memoirs to the works of Charles Dickens describe the unimaginable and often horrifying squalor faced by residents of London (Leon, 2008). Mortality in England in the late 1800s was twice as high in urban areas than in rural areas and outbreaks of diarrheal diseases, typhoid, tuberculosis and pneumonia were exceedingly common (Godfrey and Julien, 2005).

Improved sanitation, clean water, and hygiene practices were the single most effective measures that ultimately contributed to the improvement of health outcomes in London. Social movements were undertaken that would eliminate rigid class divisions and replace slums with

acceptable housing, steps that were critical to facilitating long-term changes in the social makeup (Godfrey and Julien, 2005).

Urbanization's "second wave." Developing countries have experienced rates of urbanization in the last 50 years that resembled growth rates in the first wave seen in Europe and the United States, but more recent and projected rates have been described as unprecedented (Godfrey and Julien, 2005; State of the World Population, 2007). Perhaps one of the greatest challenges faced today is that the influx of rural immigrants into urban centers is occurring in countries already bearing an inequitable share of the global disease burden which have little capacity to handle crises of such great magnitude. Another important factor distinguishing this "second wave" of global urbanization from other periods of urban growth is the absence of simultaneous growth of per capita income that might help to offset the strain of planning and scaling up services (Godfrey and Julien, 2005).

Cities with greater than 1 million people—411 cities—house more than 39% of the global population, yet encompass less than 3% of the total land area. One billion people live in Africa today and 294 million reside in urban areas, but the urban population is expected to double by 2030 with minimal or no increase in the rural population (Godfrey and Julien, 2005; State of the World's Population, 2007). By 2025, UN-HABITAT projects substantial percent increases of urban growth in some of Africa's most populous cities, including Dar es Salaam (over 80%), Nairobi (just under 80%), Kinshasa (70%), and many others, with extremely high proportions of residents in these cities living in slums, (Figure 1) (The Urbanization of Africa, 2010). Certain countries in Africa are projected to have between 90% and 100% of urban residents living in slum conditions (Figure 2). The total Asian population living in urban areas is also expected to double from 1.36 billion to 2.64 billion (The Urbanisation of Africa, 2010). The

greatest proportion of urban residents in Asia living in slums will be found in the South Asia region (58%), followed by 28% of urban residents in East Asia and 28% of urban residents in Southeast Asia (Ooi & Phua, 2007). The greatest proportions of urban slum populations in the world are concentrated in countries in sub-Saharan Africa and Asia, especially South Asia (Figure 2).

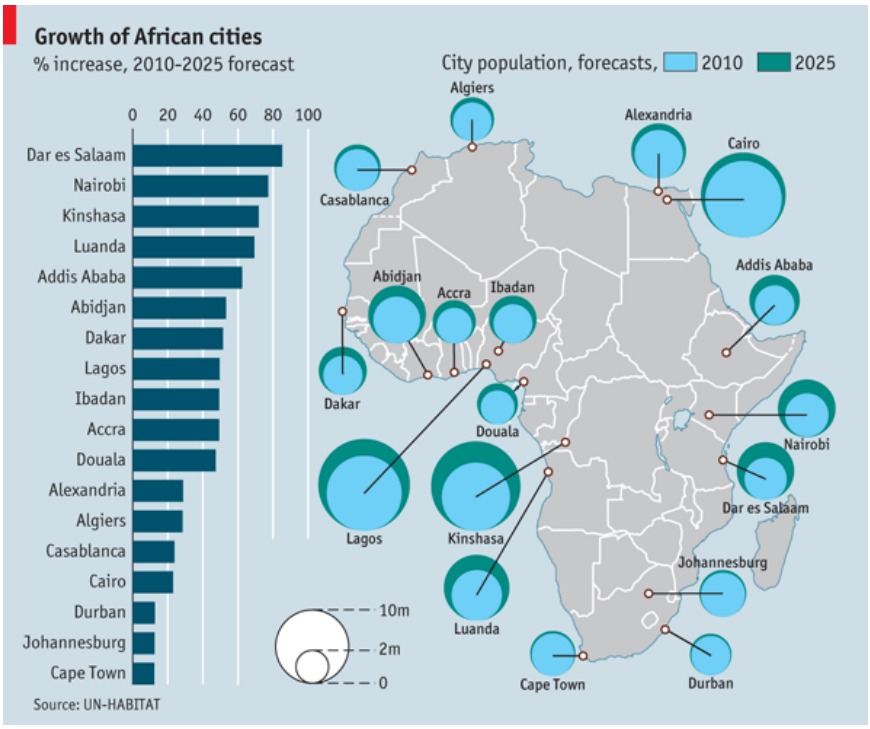

Figure 2. Forecasted growth of African cities, 2010-2025. (The Urbanisation of Africa, 2010)

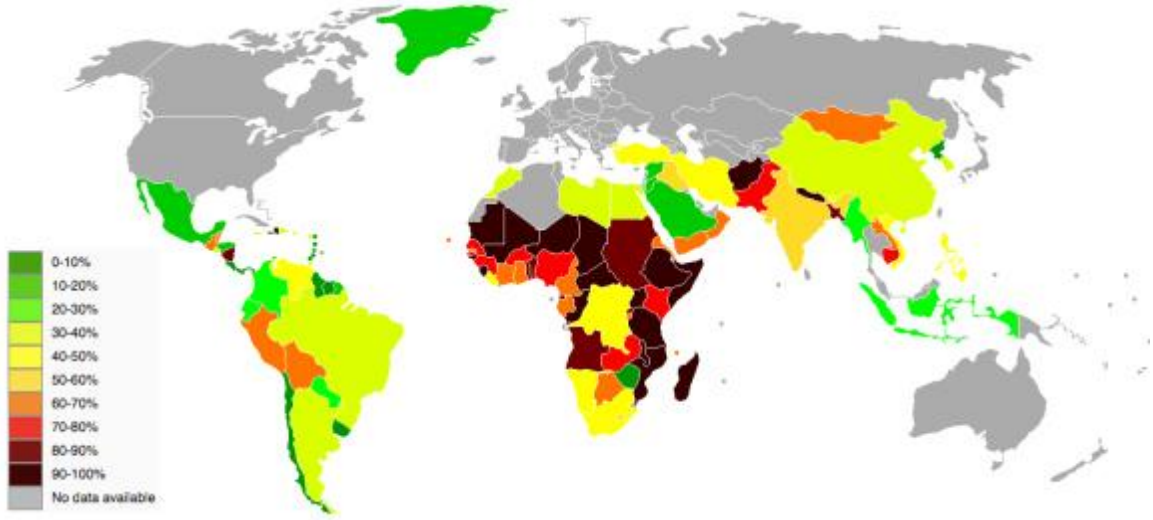

Figure 1. Proportion of urban population living in slums by country, 2010-2025. (UN-HABITAT, 2001)

Epidemiological transition and health. People may choose to migrate from rural to urban areas because of the promise of greater opportunities for employment, education, access to healthcare services, or to be closer to family. Alternatively, they may be forced to move because of unexpected displacement by civil unrest, war, or natural disaster. (Godfrey and Julien, 2005). Regardless of the driving forces, when the rate of urbanization exceeds the capacity of a government to provide basic resources to its citizens, poverty and disparity is never far behind. Consequently, the formation of slums, shantytowns, squatter housing, and informal settlements is driven by the often unplanned nature of cities and the inability to adequately accommodate huge numbers of rapidly-arriving immigrants. The plight of urban slum dwellers is characterized by a lack of durable and affordable housing, inadequate access to clean water and improved sanitation, and insecure employment (State of the World Population, 2007). Many people are often crowded into small living spaces within communities that are extremely densely populated. Because these settlements lack formal legal or political recognition, slum dwellers are unable to vote, are afforded few rights and protections, and are generally ignored and unaccounted for in health service planning (Patel and Burke, 2009).

Crowding, inadequate sanitation infrastructure and lack of clean drinking water increase the likelihood of exposure to many pathogens transmitted by feces and respiratory secretions, including diarrheal diseases such as cholera and typhoid, intestinal parasites, tuberculosis, and influenza among others. Ninety percent of children under the age of 5 with malnutrition live in sub-Saharan Africa and South Asia (Olack et al., 2011).

Concurrent to the increased risk of infectious diseases associated with urbanization are the chronic diseases associated with lifestyle changes that tend to occur in the urban environment, such as sedentary behaviors and availability and consumption of high starch, high-

fat processed foods contribute to the development of chronic conditions like hypertension, overweight and obesity, type II diabetes, heart disease, and stroke (Phillips, 1993; Mutatkar, 1995; Moore, Gould, & Keary, 2003; Leon, 2008; Khan, 2013). Other concerns related to the built environment include motor vehicle accidents and injuries such as burns, crime, environmental exposures such as air pollution, and industrial waste. (Mutatkar, 1995; Wong, Nyachieo, Benzekri, Cosmas, Ondari, Yekta, Montgomery, Williamson, & Breiman, 2014).

Researchers have posited with great empirical evidence that an epidemiological transition is underway in the developing world in which non-communicable diseases associated with urban lifestyle changes are on the rise, while hygiene and crowding-associated infectious diseases are simultaneously prevalent, sometimes referred to as a double burden of disease (Yajnik et al., 2013; Agyei-Mensah & de-Graft Aikins, 2010). The rise of non-communicable diseases should not result in infectious diseases being viewed as less of a priority, but rather, a reason to evaluate and address the risk factors more holistically (Rice, 2011). Studies suggest that the epidemiological transition may be occurring at different rates, but the basic concept illustrates the substantial challenges faced by developing countries, where morbidity and mortality are greatest, resources are poorest, infrastructure is weakest, and projected rates of urban growth are expected to skyrocket.

1.2 Statement of the Problem

Public health scientists and urban planners alike are at a critical juncture where decisions must be made to address the current and future challenges created by unprecedented rates of urbanization occurring in the most resource-constrained regions of the world, where cities are already reeling from the influx of citizens they have little capacity to serve. Disparities have

always persisted in cities, and the urban centers of today are rife with inequitable distribution of health and wealth. The formation of urban slums gives rise to many conditions which increase the risk of developing a variety of infectious and non-communicable diseases.

Until recently, health data were disaggregated no further than at the urban and rural level. Aggregated data may be misleading and incomplete because they mask intra-urban and intra-rural differences in health outcomes. For over a decade, researchers have made regular and repeated recommendations that disaggregated data be collected at the urban neighborhood level to more accurately characterize health inequities and plan appropriate and targeted interventions. Such data have not been systematically collected or pooled, and no known comprehensive reviews have been published to date that examine what is known about disease prevalence in urban slums in Africa and South Asia, what gaps remain in our understanding of urbanization and health, what studies should be conducted, and what policy and program decisions are supported by the existing literature.

1.3 Statement of Purpose

The purpose of this review is to synthesize existing disease surveillance research conducted in urban slums to understand the current and potential burden of infectious and non-communicable disease due to urbanization-related factors, such as poor infrastructure, overcrowding, and lifestyle changes in African and South Asian cities. Characterizing the baseline prevalence and epidemiology of diseases in urban slums and urban centers and associated risk factors is an essential step in the development of evidence-based interventions and the pursuit of relevant policy changes. Systematically identifying limitations and gaps in the

current knowledge base also facilitates the prioritization of future research and resource allocation to address the most critical public health problems with greater efficiency.

1.4 Research Questions

This review seeks to address the following questions:

1. What is the current and projected burden of infectious and chronic disease due to environmental conditions such as poor infrastructure, overcrowding, and lifestyle changes associated with urbanization and urban slums in African and Asian cities?

2. What interventions, policies, and programs that have been implemented thus far have been found effective and are considered best practices for combating health and other problems associated with urbanization? Similarly, what efforts have failed and why?

3. What are the existing gaps in knowledge in the intersecting fields of urbanization and health, and what recommendations can be made going forward to shift the impact of urbanization from negative to positive?

Chapter 2: Methods

General Cochrane methods were utilized for this descriptive review, which included a defined research question, a specific population, and a clear outcome of interest. Intervention and comparison groups were not applicable to the research question. Specific inclusion and exclusion criteria were developed and applied to published peer-reviewed literature in PubMed. A meta-analysis was not conducted (Higgins & Green, 2011).

This study involved a review of the literature for articles published in the PubMed database regarding the impact of urbanization on the burden of infectious and chronic diseases in urban areas and slums in Africa and South Asia. Countries in the World Bank South Asia region include Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. Supplementary information about urbanization and health was accessed from reports available from the World Health Organization and various United Nations organizations.

All searches in PubMed included ("Africa" OR "Asia") and combinations of search terms related to urbanization ("urbanization", "urban health", "urban poverty", "urban slum", "informal settlement", "epidemiological transition", "nutrition transition", "surveillance", "epidemiology") and diseases or conditions ("health", "disease", "infectious", "non-communicable", "chronic", "diarrhea", "cholera", "typhoid", "safe water", "sanitation", "influenza", "tuberculosis", "respiratory", "cardiovascular", "diabetes mellitus", "hypertension," "obesity", "stroke").

Citations were exported to EndNote. Title and abstracts were reviewed for all potentially relevant studies and then evaluated using established inclusion and exclusion criteria. The inclusion criteria utilized for this review included:

- Empirical studies that measured the burden of an infectious disease (diarrheal illness, intestinal parasitic disease, other diseases related to water and sanitation, or respiratory diseases) or a non-communicable disease (cardiovascular disease, hypertension, overweight, obesity, or diabetes mellitus) related to an aspect of the urban environment such as urbanization infrastructure, crowding, diet, and exercise;
- Conducted in Africa or South Asia;

- Population studied includes residents of urban areas or urban slums;
- Published between 2009 and 2014;
- Published in English; and
- Full text available through the Emory Library or other catalog system.

Exclusion criteria included:

- Reviews, non-empirical studies, or studies that measured burden of a disease outside the scope of this work (previously stated to include diseases associated with urban infrastructure, crowding, and lifestyle), including but not limited to injuries, sexual health, environmental health, mental health, and a number of zoonotic and vector-borne diseases;
- Conducted outside of Africa or Asia;
- Population studied does not include residents of urban areas or urban slums;
- Published prior to 2009;
- Published in a language besides English; and
- Full text not available through the Emory Library or any other catalog system.

In an effort to obtain the most accurate prevalence data available for cities undergoing dynamic changes due to rapid urbanization, it was particularly pertinent to include studies published in the last five years. Limiting to the last five years also increased the manageability of the articles to review because the number of ever-published articles was vast. Non-English articles were excluded because of the language limitations of the reviewer. The decision to exclude certain diseases and conditions, such as issues of mental and sexual health, injuries, environmental hazards, and vector-borne diseases, was made because their relationship with the

risk factors specified in the original research question, i.e. water and sanitation infrastructure, overcrowding, and sedentary lifestyle changes, are indirect or unclear. Thorough treatment of these issues is outside the scope of this work.

Full text was obtained for all studies that met the inclusion criteria. The reference sections of abstracted articles were also scanned to identify additional articles of interest, and identified references were then manually located in PubMed. Articles which were discovered during the course of searches which were published prior to 2009 were included occasionally when they added context and useful information to support the findings from more recent studies. Relevant data were extracted from articles and managed using a Microsoft Excel spreadsheet. Abstracted information included reference, region and country the study was conducted in, diseases(s) studied, study design, sample size, and key findings. Studies were categorized by topic as either infectious or non-communicable.

Submission to IRB was not required in this review as human subject research was not conducted.

Chapter 3: Results

The PubMed database search identified 1251 published articles that included the search terms. Limiting the results to articles published in the last 5 years reduced the number to 402 relevant articles. Review articles and studies not conducted in South Asia or Africa were removed from further consideration (n=173). Citations for the remaining 229 articles were exported to Endnote and abstracts were screened for eligibility using the exclusion criteria. Articles that did not meet the inclusion criteria were most often excluded because disease burden was not measured, the disease studied was outside the scope of this work, or the population

studied was not an urban slum (n=168). Full text was obtained for the remaining 61 articles included in this synthesis. Articles were reviewed and key information was abstracted into an Excel database. Seventeen articles describe infectious diseases in Africa, 14 describe non-communicable diseases in Africa, 15 describe infectious diseases in South Asia, and 15 describe non-communicable diseases in South Asia. Most studies reviewed from Africa were conducted in Kenya (58%), and all studies reviewed from South Asia were conducted in India (50%), Bangladesh (27%), or Pakistan (23%) (Appendix A).

3.1 Burden of infectious diseases in African urban centers

Diarrheal illnesses. Infectious diseases in urban areas are thought to be exacerbated by characteristics such as poor water and sanitation infrastructure, overcrowding, and other conditions of poverty. A cross-sectional study conducted in 2006 explored the relationship between many of these environmental characteristics and the incidence of cholera in an urban slum in Dar es Salaam, Tanzania. (Penrose, Caldas de Castro, Werema, & Ryan, 2010). A total of 8,753 cases of cholera were recorded, and the mean incidence rate was 15.8 cases per 10,000 people. Significant associations were found between cholera incidence and socioeconomic status, access to sanitation, percentage of informal residents, and population density. Cholera incidence was found to increase one percent for every one percent increase in percentage of informal residents in a ward, and two percent for every increase in population density of 1000 persons per square kilometer.

The incidence rate of shigellosis in residents of the Kibera urban slum in Nairobi, Kenya was ascertained through population-based surveillance between 2007 and 2010 by the Kenya Medical Research Institute/ Centers for Disease Control and Prevention (KEMRI/CDC) research

group (Njuguna, Cosmas, Williamson, Nyachieo, Olack, Ochieng, Wamola, Oundo, Feikin, Mintz, & Breiman, 2013). The overall crude incidence rate in the study population was 0.29%, which the authors commented was somewhat higher than the overall adjusted incidence rate of 0.2% found in a study conducted in urban slums in Asia. The overall adjusted incidence rate was 0.4%, which the researchers estimate translates into 17,000 cases and 170 deaths attributable to shigellosis in Kibera each year. The highest adjusted incidence rate was observed in adults 35 to 49 years of age (1,575/100,000 person years of observation), and rates varied significantly by geographic zone of residence and sex. Molecular characterization revealed that *Shigella flexneri* was the species most commonly isolated from stool samples, and species were frequently resistant to first line antibiotics. Of particular interest to the authors was the unexpected year-round persistence of shigellosis in the community with a lack of seasonality, which they theorized to be the result of inadequate sanitation and various opportunities to come into contact with raw sewage in the community.

Govender, Barnes, and Pieper (2010) conducted a cross-sectional survey in Cape Town, South Africa to characterize the living conditions and the prevalence of diarrheal illness of individuals living in four low-cost housing communities. The backyards of the houses in these communities had regularly been exploited to build informal structures that the authors refer to as shacks; the authors administered their questionnaires to 1,080 individuals living in both types of households (n=710 individuals in 173 main houses and n=370 individuals in 163 shacks) to investigate the relationship between social and health disparities. Self-reported incidence of diarrhea in the two weeks prior to the survey was 14% overall and 4.6% in children under the age of 10, which the authors say is comparable to rates found in studies with similar study designs in Kayamandi, South Africa (13.1%) and Karachi, Pakistan (14.4%). Diarrheal disease

was reported by more than a third of all households overall, and by a significantly higher proportion of main houses than shacks (40.5% vs 23.3%, $p<0.01$). The distribution of toilets and the condition of sanitation in the community may play an important role in the differential patterns of diarrheal illness observed between the household types. A single toilet was shared by the occupants of each plot of land (ranging from two to 18 individuals) and was located either inside or adjacent to the main house. Researchers asked to observe the toilet facilities during questionnaire administration and found that almost two thirds of the toilets were not functional and had blocked or overflowing drains.

A large study quantifying the incidence of rotavirus enteritis in the Kibera urban slum of Nairobi, Kenya, and rural Lwak in western Kenya, was conducted between 2007 and 2010 by the KEMRI/CDC research group (Breiman, Cosmas, Audi, Mwiti, Njuguna, Bigogo, Olack, Ochieng, Wamola, Montgomery, Williamson, Parashar, Burton, Tate, & Feikin, 2014). Rotavirus was detected in 9% of tested stools. The overall crude and adjusted incidence rates of gastroenteritis were similar between the two sites (adjusted rates= 1157/100,000 PYO in Kibera and 1427/100,000 PYO in Lwak), and cases of gastroenteritis in rural Lwak were more likely to be caused by rotavirus than cases from urban Kibera (relative risk= 1.46). Adjusted incidence was highest in children 12-23 months old (14,986/100,000 PYO in Lwak and 12,287/100,000 PYO in Kibera), and similar rates were also seen in children less than a year old. The highest rates of illness not in children less than 5 years of age were in adults 18-34 years in Lwak (982/100,000) and 35-49 years in Kibera (437/100,000). Based on the overall under 5 incidence rates calculated for the surveillance sites (6779 cases per 100,000 children in Lwak and 5887 per 100,000 children in Kibera), the authors estimate that there are more cases of rotavirus-associated gastroenteritis in children under the age of 5 in Nyanza province surrounding Lwak

than in the urban slums of Nairobi (54,500 cases compared to 16,750, respectively), suggesting that the burden of rotavirus is not directly affected by slum conditions, and, in this case, may have been greater in the rural area.

Intestinal parasitic diseases. Poor sanitation, crowding, and persistent environmental contamination are all believed to contribute to the prevalence of soil transmitted helminth (STH) infections and reinfections in children in urban communities. A cross-sectional study was conducted in 2012 to ascertain the prevalence of STH infection and nutritional status of 692 preschool and school-aged children in the Kibera slum of Nairobi, Kenya (Suchdev, Davis, Bartoces, Ruth, Worrell, Kanyi, Odero, Wiegand, Njenga, Montgomery, & Fox, 2014). Stool samples were collected and processed for the presence and intensity of STH ova; 40.7% of children had any STH infection (*Ascaris, Trichuris,* or hookworm), and 7.5% of preschool and 10.8% of school children had *Ascaris/ Trichuris* coinfections. Hookworm infection was very rare in the population, with only one school-age child found to have positive stool. Preschool age children with STH infections were found to have significant micronutrient deficiencies including vitamin A and iron. The overall prevalence of 40% STH in the study population is considerably higher than reported for school-age children in the city of Nairobi (12.9%) and children aged 10-18 years from slums in rural Western Kenya (16.2%), and the authors stress the importance of targeting this age group in urban slums for regular integrated deworming/ micronutrient supplement programs.

The burden of STH was also found to be particularly high in a cohort study of children living in 10 slums in Durban, South Africa between 1998 and 2000 (Appleton, Mosala, Levin, & Olsen, 2009). Prevalences and intensities of *Ascaris lumbricoides, Trichuris trichiura*, and

hookworm infections were measured for 996 children 2 to 10 years of age at baseline and again at 4 to 6 months and 12 months post-deworming treatments to evaluate the intervention's impact on reinfection. *A. lumbricoides* prevalence at baseline ranged from 81.7% to 96.3% (mean=89.2%) and almost half of the infections were characterized as moderate intensity. The baseline prevalence of *T. trichiura* was also high and ranged from 54.4% to 86.2% (mean=71.6%).. *T. trichiura* infection intensities were characterized as low in 47.7% of cases. Hookworm prevalence was very low in the study population (mean=4.7%; range=0% to 20.1%). In 6 out of 10 slums, less than 11% of households had access to toilet facilities. Although environmental contamination with STH ova was not measured in this study, the authors propose that the variable levels of sanitation coverage in the slums may contribute to the prevalence of reinfection months after treatment with albendazole.

Similar assessments of the association between poor urban access to water and sanitation and the prevalence of protozoa and helminth infections in children were made by researchers who conducted a cross-sectional study from 2010-2011 in the Mukuru informal settlement of Nairobi, Kenya (Mbae, Nokes, Mulinge, Nyambura, Waruru, & Kariuki, 2013). Stool samples were collected from children less than 5 years of age who presented at district outpatient clinics or were hospitalized with diarrheal illness and examined by microscopy for the presence of protozoa. Fifteen different types of parasites were isolated from specimens. Species that were most prevalent included *Entamoeba histolytica* (13.8%), *Cryptosporidium* spp. (6.7%), and *Giardia lamblia* (5.8%). The authors note that *Cryptosporidium* infection was significantly more likely in patients who were HIV positive compared to seronegative patients (19.5% vs. 7.3%). Nearly 26% of specimens were positive for at least one parasite and the prevalence was higher among outpatients (38.9%) than inpatients (21.1%). Increasing age was significantly associated

with infection, and 34.9% of 37-48 month olds were stool-positive for at least one parasite. Polyparasitism, especially with *E. histolytica* and another or other parasite, was relatively common and was detected in 12% of samples. The epidemiological findings were similar to those in other studies in Kenya and Uganda, although overall prevalence was lower. The authors suggest that this may be because molecular detection methods used in these studies were more sensitive than microscopy.

Impact of nutritional status on disease. It is also relevant to address the association of nutritional status with subsequent morbidity and mortality caused by infectious diseases. The synergistic relationship between nutrition and disease has been well-established (Scrimshaw, Taylor, & Gordon, 1968; Pelletier, 1995; Solomons, 2007). Ninety percent of the global burden of malnutrition is found in children under the age of 5 in sub-Saharan Africa and Asia, as is the highest prevalence and mortality of diarrheal and respiratory illnesses (Olack, Burke, Cosmas, Bamrah, Dooling, Feikin, Talley, & Breiman, 2011). Overall mortality and deaths due to infectious etiologies remain high in urban slum settings remains high, and clinical presentations of cough or diarrheal illness were significantly associated with mortality in recent study in Kibera (Olack, Feikin, Cosmas, Odero, Okoth, Montgomery, & Breiman, 2014). Malnutrition has been found to be the underlying cause of death in 50% of child deaths in developing countries, and surprisingly, mild or moderate malnutrition is responsible for the vast majority of deaths—only 17% of child deaths are characterized by severe malnutrition (Pelletier, Frongillo, Schroeder, & Habicht, 1995). A consistently strong relationship has been established between malnutrition and mortality associated with diarrheal and acute respiratory infections, but the relationship is not as clearly for other diseases such as malaria or measles (Rice, Sacco, Hyder, & Black, 2000).

A study of primary school children in Uganda revealed that despite a relatively low burden of helminth infection in the population (16% prevalence of any helminth with light intensity), stunting, underweight, and moderate malnutrition were common (Lwanga, Kirunda, & Orach, 2012). Stunting was more common in children attending schools in urban slums than in rural areas, a finding supported by a similar study of malnutrition in urban slum children in Nigeria (Amuta, Houmsou, & Soumay, 2009). Disabling morbidity related to nutritional status is a common cause and effect of diarrheal disease and intestinal worm infections. A malnourished child is more susceptible to infection, and intestinal infection may rob a child of essential nutrients–a self-perpetuating cycle. Children who are malnourished have slowed cognitive development and may not reach their full potential in school or as able workers in society Treatment for intestinal parasites can positively impact not only nutritional status and performance, but the survival and lifelong trajectory of an individual (Guerrant, Oria, Moore, Oria, & Lima, 2008).

Although malnutrition interventions have typically been implemented in rural areas where the burden is greatest, recent evidence suggests that nutrition and food insecurity is also critical to the health of children living in urban slums (Olack et al., 2011). A nutrition and anthropometric survey was conducted in Kibera between 2007 and 2008 by KEMRI/CDC to investigate the prevalence of acute and chronic malnutrition in the settlement following a short period of political unrest and food security. In this study, Olack and colleagues found evidence to suggest that chronic malnutrition was an ongoing rather than isolated issue in the community and recommended that urban slums be targeted in the future for feeding and nutrition programs.

Additional water and sanitation-related illnesses. Typhoid fever is caused by *Salmonella* Typhi bacteria shed in the feces of infected individuals and often transmitted through sewage-contaminated water used for drinking or washing food. The burden of typhoid fever in Kibera and Lwak was characterized through population-based surveillance between 2007 and 2009 (Breiman, Cosmas, Njuguna, Audi, Olack, Ochieng, Wamola, Bigogo, Awiti, Tabu, Burke, Williamson, Oundo, Mintz, & Feikin, 2012). Blood cultures were obtained and processed for individuals presenting at the study clinics with respiratory symptoms meeting the case definitions. Non-typhoidal species of Salmonella were isolated from 1.6% of blood cultures in Lwak compared to 0.3% in Kibera ($p<0.0001$), while *Salmonella enterica* serovar Typhi (*S. typhi*) was isolated more frequently from urban clinic specimens than rural clinic specimens (6.4% and 0.6%, respectively). Similar high rates of typhoid fever have been found in urban slums in Asia, including Karachi, Pakistan, Kolkata, India, and Dhaka, Bangladesh, while higher rates of non-typhoidal Salmonella have been found in rural areas (Brooks, Hossain, Goswami, Sharmeen, Nahar, Alam, Ahmed, Naheed, Nair, Luby, & Breiman, 2009; Naheed, Ram, Brooks, Hossain, Parsons, Talukder, Mintz, Lubya, & Breiman, 2010; Khan, Ochiai, von Seidlein, Dong, Bhattacharya, Agtini, Bhutta, Do, Ali, Kim, Favorov, & Clemens, 2010). Dense population and poor water and sanitation infrastructure such as that found in urban slums may be risk factors for typhoid fever, while non-typhoidal Salmonella transmission is associated with animals and has a possibly coendemicity with malaria, risk factors of rural areas.

A 2006-2009 population-based surveillance study compared the incidence of nontyphoidal Salmonella in rural and urban sites in Kenya (Tabu, Breiman, Ochieng, Aura, Cosmas, Audi, Olack, Bigogo, Ongus, Fields, Mintz, Buron, Oundo, & Feikin, 2012). A pathogen was isolated from more blood cultures at the urban site than the rural site (10.8% vs

4.3%, respectively), but a greater proportion of the pathogens isolated from rural specimens were nontyphoidal strains (39%) than urban specimens (3%). In contrast, the incidence of typhoidal Salmonella in Kenya has been found to be higher in urban Kibera than in rural Lwak (Breiman et al., 2012). The highest crude incidence rates of *S. typhi* in Kibera were observed in children 5-9 years of age (596 cases per 100,000) and 2-4 years of age (521 cases per 100,000) and were 20 times higher than rates in respective age groups in Lwak. The authors compare this rate to similarly high figures observed for children 2-4 years of age in slums in Asian cities such as Kolkata, Jakarta, Karachi, and Dhaka. The overall adjusted incidence rate of *S. typhi* bacteremia in Kibera was 843 cases per 100,000 person-years of observation, almost twice as high as the incidence in Lwak (445 cases per 100,000 person-years of observation). Incidence rates in Kibera for children under the age of 10 were even higher than in Lwak and increased with age: 2.4 times higher for 0-1 age group, 3 times higher for 2-4 year old age group, and 8 times higher for the 5-9 year old age group. Adjusted incidence for adults older than 17 years of age is actually higher in Lwak than Kibera (625.6 cases per 100,000 vs 231.3 cases per 100,000), which may represent population differences in early typhoid immunity between the urban and rural populations.

Leptospirosis is an emerging, rodent-transmitted bacterial disease that is likely highly under-characterized due to its nonspecific symptoms and variable clinical presentation, but also likely to be of high-risk exposure to residents of urban slums due to frequent contact with reservoir rodents. Transmission may occur when people encounter soil or water contaminated with rodent urine containing *Leptospira;* crowding, poor water and sanitation, and conditions amenable to the presence of rodents make such encounters probable if not inevitable. A study in Kibera was undertaken to characterize the prevalence of rodents carrying bacteria in their

kidneys as well as the frequency of human-rodent encounters to understand the community's risk of exposure (Halliday, Knobel, Allan, Bronsvoort, Handel, Agwanda, Cutler, Olack, Ahmed, Hartskeerl, Njenga, Cleaveland, & Breiman, 2013). Almost 20% of rodents were found to be carriers of the pathogen, and surveys administered to residents suggests that sightings within households are a daily occurrence. The potential for exposure and transmission is great, and further studies will be necessary to elucidate the disease burden in urban slum populations.

Respiratory illnesses. The distribution of tuberculosis in urban and rural settings is not well defined; it is somewhat unclear in which setting prevalence is higher. The living conditions, high prevalence of HIV and poor healthcare infrastructure may all increase the magnitude of the tuberculosis in these settings, but underreporting may also be very common because of the limitations of surveillance in developing countries. Recent studies in Bangladesh and China indicate that rural TB prevalence is higher than aggregate urban prevalence, but that within-city rates for high-risk populations like urban slum dwellers may be much greater (Banu, Rahman, Uddin, Khatun, Ahmed, Rahman, Husain, & van Leth, 2013; Chen, Shu, Wang, Hou, Xia, Xu, Bai, Nie, Cheng, & Xu, 2013).

A 2001 study of TB in an urban area of Kampala, Uganda was undertaken by a group from the World Health Organization to study the urban distribution of TB and found that the TB incidence rate was almost five times higher than the national average (9.2 cases per 1000 vs 2 cases per 1000) (Guwatudde, Zalwango, Kamya, Debanne, Diaz, Okwera, Mugerwa, King, & Whalen, 2003). A study conducted in 2005 in Kampala, Uganda employed active case finding methods to estimate the prevalence of chronic cough (characterized as cough lasting longer than 2 weeks) and the prevalence of active tuberculosis (TB) in an urban slum community considered

high risk for TB transmission due to overcrowding (Sekandi, Neuhauser, Smyth, & Whalen, 2009). From a community-based survey of 753 households, researchers found that 20% of the 930 individuals surveyed had chronic cough, and of these, identified 33 (18%) previously-undiagnosed smear positive cases of active TB, The authors note that similar studies of people with chronic cough yielded lower prevalences of active TB, including 4% in South Africa and 13% in Ethiopia, but reasoned that this could be attributable to underlying factors specific to their study such as the high rate of TB in Kampala and the high-risk urban setting. Delays between symptom onset and healthcare-seeking behavior in a crowded urban center pose significant challenges for interrupting the spread of a highly infectious respiratory disease such as TB, and active case finding may have great utility in earlier linkage to treatment.

Relatively little is known about the epidemiology of influenza in sub-Saharan Africa, and data clearly differentiating whether the urban environment increases risk of transmission or affects the epidemiology are not available. A population-based surveillance study was conducted between 2007-2010 in Kibera and Lwak to characterize ARI and influenza-like illness (ILI) in the communities (Katz, Lebo, Emukule, Njugana, Aura, Cosmas, Audi, Junghae, Waiboci, Olack, Bigogo, Njenga, Feikin, & Breiman, 2012). In Lwak, 21.9% of patients presenting to the clinic with ARI that were sampled tested positive for influenza; 26.7% of patients presenting to the clinic in Kibera with ARI were positive for influenza. ARI and influenza incidence was similarly high at both the rural and urban sites and the greatest burden was in children less than 2 years of age. It is plausible that a viral disease transmitted by respiratory droplets would spread rapidly in an urban slum characterized by crowded living conditions and frequent human contact, but future studies will be needed to understand whether risk is increased in urban settings compared to rural settings.

Household reporting of ILI was higher in rural Lwak than in Kibera; the authors suggested that increased healthcare-seeking behavior for these syndromes may be related to the differential rural prevalence of diseases such as malaria that have frequently severe outcomes. Healthcare utilization rates at both sites were lower than in comparable countries; consequently, the authors project that the true incidence of ARI in the population may be 3-5 times higher than reported (Katz et al., 2012).

The incidence rate of ARI in children less than one year old was assessed in a one-year cohort study of 571 children living in Soweto, a low-cost urban housing community on the outskirts of Johannesburg, South Africa between 2000 and 2001 (Kristensen and Olsen, 2006). Throughout the study period 489 instances of ARI were recorded and 75% were within the season for respiratory syncytial virus (RSV). Incidence of ARI was 1.56 episodes per child year. RSV was the most common organism isolated (12.6%), followed by parainfluenza 3 (3.4%), influenza A (1.1%), and parainfluenza 1 (1.1%). Coinfection with adenovirus was also reported. A number of relevant risk factors for respiratory illness were investigated including household crowding and sleeping conditions, sanitation, and indoor air pollution, but none were found to be significantly associated with incidence of disease, with the exception of a significant relationship between crowding and disease severity which the authors suggest may be the effect of increasing infectious dose as proximity increases. Other studies have found a significant relationship between respiratory disease and several modifiable environmental risk factors including household size of five or more persons, sleeping with multiple persons, and a coughing sibling (Berman, 1991; Azizi, Zulkifli, & Kasim, 1995). The authors state that their insignificant risk relationships may be a consequence of a lack of statistical power, or there may be other intervening variables which dispute the true relationship. Respiratory illness risk factors and

transmission in urban areas compared to rural areas are not yet well-defined and should be studied further to inform risk reduction strategies.

Household and clinic-based surveillance was conducted in Kenya from 2006 to 2008 to assess the burden of acute respiratory illness, diarrheal illness, and acute febrile illness in urban Kibera and rural Lwak, (Feikin, Olack, Bigogo, Audi, Cosmas, Aura, Burkel, Njenga, Williamson & Breiman, 2011). Rates of all diseases studied were higher in children less than 5 years of age than in older children. It is interesting to note that case-fatality ratios and overall mortality rates were higher in Lwak than in Kibera, but that incidence of acute lower respiratory infection (ALRI) and diarrheal syndromes was higher in Kibera. It is possible that co-morbid conditions (like malaria, other parasitic diseases or malnutrition) contributed to differences in mortality rates. Rates ascertained from household surveys were much higher than rates from clinics, especially at the rural site.

3.2 Burden of non-communicable diseases in African urban centers

Cardiovascular disease and modifiable risk factors. Cardiovascular disease (CVD), including heart disease and stroke, is a leading cause of death in developing countries and is attributable to a number of lifestyle-related risk factors such as hypertension obesity, and diabetes mellitus ("Cardiovascular Disease Risk Factors," 2014). Another risk factor for CVD is being diagnosed with metabolic disease, which is defined as having at least three of the following risk factors: excess abdominal fat, high triglycerides, low HDL cholesterol, hypertension, or high fasting blood sugar ("What Is Metabolic Syndrome?," 2011). In sub-Saharan Africa in 2010 CVD etiologies ranging from atherosclerosis and hypertension to infection and inflammation tended to occur at a younger age than in developed countries and

caused 8.8% of deaths in the region—in fact, at 64.9 years the mean age of death due to CVD in Africa was the lowest of any other region by 3 years (Moran, Forouzanfar, Sampson, Chugh, Feigin, & Mensah, 2013). Type II diabetes (diabetes mellitus) is impacted by similar risk factors and is the type of diabetes found most often in Africa (Duboz, Chapuis-Lucciani, Boetsch, and Gueye, 2012).

Hypertension. The underlying risk factors of poor diet and exercise are becoming increasingly widespread in urban areas of sub-Saharan Africa, and hypertension is very common and on the rise from 80 million adults in 2000 to a projected 150 million adults by 2025 (van de Vijver, et al., 2013). Physical inactivity and hypertension are strongly related to the risk of heart attack and stroke ("Cardiovascular Disease Risk Factors," 2014). The prevalence of hypertension was assessed in Old Town, an urban district of Mombasa, Kenya in 2008 (Jenson, Lali Omar, and Athman Omar, 2011). Of 469 urban dwellers in the study, 32.6% of adults had hypertension and less than 25% were aware of steps to prevent or treat the disease. Although the preponderance of evidence describing the burden of hypertension in Africa is substantial, studies have limited comparability because of differences in study design, case definitions, and measurement criteria. It has been proposed that some of the differences in prevalences across Africa are attributable to being in different points along the spectrum of the epidemiological transition (van de Vijver, et al., 2013). As countries become more developed and urbanized, either gradually or explosively, there tends to be a corresponding rise in the prevalence of chronic diseases; Ghana experienced its most expedient rural to urban migration and rise in chronic disease burden during the recovery period following a 1970s economic downturn in the country, and the epidemiology shows increased prevalence of hypertension, diabetes, and obesity (Agyei-Mensah & de-Graft Aikins, 2010). For instance, the overall prevalence of hypertension in

adults living in the Viwandani and Korogocho slums of Nairobi (19%) was relatively low compared to other African sites but may merely be indicative of an early stage of the polarized protracted model of urbanization as has been described for Ghana (Omran, 1971; Agyei-Mensah & de-Graft Aikins, 2010; van de Vijver, Oti, Agyemang, Gomez, & Kyobutungi, 2013)

Metabolic disease. A cross-sectional study was conducted of Langata, Nairobi in 2008 to quantify the prevalence of metabolic syndrome in an urban population, as defined by the 2009 criteria of the International Diabetes Federation as having three of the following CVD risk factors: large waist circumference, high HDL cholesterol, high triglycerides, hypertension or high fasting blood glucose or diabetes (Kaduka, Kombe, Kenya, Kuria, Bore, Bukania, & Mwangi, 2012). Overall prevalence was significantly higher in women (40.2%) than in men (29%), which the authors suggest may be modified by differences in socioeconomic status and/or education. Hypertension, higher waist circumference, and low HDL were the most commonly reported risk factors for both sexes, reported in 80%-97% of individuals diagnosed with metabolic syndrome.

Similar CVD risk factors were measured by Delisle, Ntandou-Bouzitou, Agueh, Sodijnou, & Fayomi (2012) in an urban and rural community in Benin, including BMI, waist circumference, blood pressure, HDL, and diabetes. All factors were more prevalent in the urban residents than rural residents, and were higher in women than in men. Income and living in a city was associated with higher BMI and WC compared to living in a village.

Overweight and obesity. The prevalence of overweight or obesity were ascertained between 2008 and 2009 in adults from the Korogocho and Viwandani slums in Nairobi (Ettarh, Van de Vijver, Oti, and Kyobutungi, 2013). Despite high levels of poverty in these slums

overweight and obesity were very high, particularly in women (43.4% vs 17.3% in men). There were discrepancies between personal perception and rating of weight as normal, underweight, or overweight compared to actual anthropometric classification. More than half of participants underestimated their BMI. Surprisingly a third of men and women in the study preferred an overweight or obese body image. Although this study did not seek participants' reasons for a particular ideal body image, evidence from other studies in sub-Saharan Africa suggest that a societal association of increased weight and increased wealth likely plays a key role in the desirability of excess weight regardless of the health implications, which presents unusual challenges for public health interventions targeting CVD and related risk factors in this population (Duda, Jumah, Hill, Seffah, & Biritwum, 2007; Adeboye, Bermano, & Rolland, 2012).

A review of Demographic and Health Survey (DHS) data from Burkina Faso, Ghana, Kenya, Tanzania, Malawi, Niger, and Senegal between 1992 and 2005 indicates that the highest prevalences of obesity in adult women are found in groups with the lowest socioeconomic status (around 50% in the lowest SES group vs 7% in the highest SES group), while having a secondary education was associated with lower rates of obesity (Ziraba, Fotso, & Ochako, 2009). The mean overall prevalence of overweight or obesity in these developing nations was quite high (31.4%; range= 23% in Malawi to 38% in Kenya). Although these figures do not represent data disaggregated to urban neighborhoods, they do illustrate that poverty and obesity are not mutually exclusive concepts in developing countries in sub-Saharan Africa. Furthermore, women are disproportionately affected by obesity than men in these populations and should be targeted for future risk reduction and management strategies (Ziraba et al., 2009; Adeboye, Bermano, & Rolland, 2012).

Heart disease. Bloomfield, Barasa, Doll, and Velazquez (2013) point out in their review of the epidemiology of heart failure in sub-Saharan Africa that the application of non-standardized definitions of hypertensive heart failure restricts the comparability of studies that have been conducted, but that the high prevalence of hypertension in urban settings is a significant risk factor.

A study of echocardiograph-diagnosed heart disease in 1252 patients presenting to a hospital in a peri-urban area of Cameroon was conducted between 2008 and 2010 (Jingi, Noubiap, Kamden, Wawo Yonta, Temfack, Kouam Kouam, & Kingue, 2013). The most common condition diagnosed in the study population was hypertensive heart disease (41.5%). When stratified for age, rheumatic heart disease was identified in 62.1% of patients 10-19 years of age, and 53.3% of patients 20-39 years of age. Children most frequently presented with heart disease of congenital origin (52.4%).

Rheumatic heart disease (RHD) is caused by inflammatory damage to the heart tissue from group A streptococcal infection and is a unique link between the double burden of communicable and non-communicable disease in urban settings. People living in urban slums, including children, are especially vulnerable to the transmission of streptococcus due to overcrowding and inadequate healthcare, and may subsequently suffer long-term cardiac damage (Essop and Nkomo, 2005). No studies published since 2009 characterizing the prevalence of RHD in urban slum populations were found in the course of this review, but figures from older surveys indicate that RHD is a significant cause of heart disease in this population that warrants future study. A cross-sectional study of 4,848 school children 5-16 years of age from an urban community in Kinshasa, Democratic Republic of Congo found that overall prevalence was 14.3/1000 and significantly higher in children from schools in slums than other urban schools

(22/1000 and 4/1000, respectively) (Longo-Mbenza, Bayekula, Ngiyulu, Kintoki, Bikangi, Seghers, Lukoki, Mandundu, Manzanza, & Nlandu, 1998).

Stroke. The top CVD-related cause of mortality in sub-Saharan Africa in 2010 was stroke, attributable for 38.8% of CVD deaths (~7.4 million) (Moran et al., 2013). Hypertension is the most common risk factor (Ntsekhe and Damasceno, 2013). The available literature characterizing the incidence of stroke was not disaggregated to the level of urban slums but several studies included urban communities; stroke incidence appears to be higher in urban settings than rural (Ntsekhe and Damasceno, 2013).

Diabetes mellitus. A 2009 survey of 600 adults 20 years and older living in Dakar, Senegal was conducted to examine the prevalence of diabetes mellitus (Duboz et al, 2012). Eighteen percent of participants were diagnosed with diabetes, and high BMI and hypertension were significant risk factors for being diabetic.

The prevalence of diabetes in adults 18 years of age and older living in Kibera was ascertained through population-based household surveillance (n=2061) during 2010 (Ayah, Joshi, Wanjiru, Njau, Otieno, Njeru, and Mutai, 2013). Diabetes was diagnosed in 5.3% of participants and was highest in the 45-54 age group. Significant risk factors associated with diabetes mellitus in this population included physical activity (75.7%), alcohol consumption (74.9%), overweight (29%), and obesity (16.3%). The odds of having hypertension were 3 times higher for people with diabetes than those without.

3.3 Burden of infectious diseases in South Asian urban centers

Diarrheal illnesses. A 2002-2003 study of four urban slums in Karachi, Pakistan described the epidemiology of diarrheal illness caused by *Shigella* and *Campylobacter* in care-seeking individuals (Soofi, Habib, von Seidlein, Khan, Muhammada, Bhutto, Khan, Rasoola, Zafar, Clemens, Nizami, & Bhutta, 2011). The annual incidence rate of diarrhea in children under 5 was 488/1000, compared to 22/1000 per year in older children. *Campylobacter* was isolated from 7% of samples, and Shigella was isolated from 4.9% of samples. A cross-sectional study of the prevalence of diarrheal illness in children under 5 years of age was conducted recently in an Indian urban slum in Aligarh, Uttar Pradesh province (Shah, Ahmad, Khalique, Azfal, Ansari, & Khan, 2012). Overall prevalence of diarrhea in the under 5 population was 36% and prevalence was even higher in children less than a year old (44%), which the authors explain are similar to findings from studies in India and Egypt (Shah et al., 2012). Mothers' knowledge of basic diarrheal caretaking was lacking, including less than 30% of mothers who knew of oral rehydration salts and knew how to prepare them correctly, but 80% were aware of at least one severe symptom that warrants medical attention. Future educational programs for mothers may be useful in closing certain knowledge gaps and reducing morbidity and mortality in a high disease burden setting like an urban slum.

A hospital-based surveillance study comparing incidence of intestinal amebiasis and Shigellosis was conducted in Dhaka, Bangladesh between 1993 and 2011 by the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) (Das, Chisti, Malek, Salam, Ahmed, Faruque, & Mondal, 2013). The authors note than intestinal amebiasis represented only 1% of patients presenting with diarrheal illness at the hospital and that incidence actually declined in the population over the study period. In children less than 15 years old, slum dwelling was significantly associated with incidence of intestinal amebiasis (adjusted OR=3.51;

95% CI= 1.69, 7.24; p= 0.001). The likelihood of a slum dweller having amebiasis was greater for those without latrine access than for slum dwellers who reported having latrine access.

A prospective birth cohort of 452 children was undertaken in India between 2002 and 2006 to examine the rates of illnesses in a slum population (Gladstone, Das, Rehman, Jaffar, Estes, Muliyil, Kang, & Bose, 2010). The mean rate of illness in the population was greater than 11 episodes per child each year, and 58% of illnesses were associated with respiratory symptoms and 18% were associated with diarrhea. Healthcare was sought for about half of all reported episodes of illness, and the authors posit that relatively high access to and utilization of healthcare services may contribute to the surprisingly low mortality in a population with such high morbidity. A quasi-experimental study by Sarkar, Sivarathinaswamy, Thangaraj, Sindhu, Ajjampur, Muliyil, Balraj, Naumova, Ward, & Kang (2013) between 2008 and 2011 also investigated diarrheal and respiratory illness and malnutrition in urban slum children in India using similar symptoms and indicators. The authors reported a similar annual rate of 12.5 episodes of illness per child. Anthropometric measurements indicate that growth failures and stunting were quite prevalent by the age of two (2/3 and 1/3 of children, respectively), and the high burden of respiratory and diarrheal illness may be a contributing factors to their malnutrition.

Surveillance for diarrheal episodes in children less than one year old conducted in Bangladesh provides confirmation of the high diarrheal disease burden and the concomitant impact on nutrition (Mondal, Minak, Alam, Liu, Dai, Korpe, Liu, Haque, & Petri, 2012). Annual diarrhea incidence(4.69 episodes per child) was only a third of what was found in India by Sarkar et al. (2013). Amebiasis, cryptosporidiosis, and giardiasis were the most common infections, and *E. histolytica* and cryptosporidium were significantly associated with more severe

outcomes in malnourished children. Malnutrition was present in 16.3% of children at birth and in 42.4% at 12 months of age. The findings inform one another: successful treatment of malnutrition should also include treatment of diarrheal illness, and malnutrition is a predictor of illness severity and is a factor that should not be neglected when treating a child for disease.

Intestinal parasitic diseases. A longitudinal study of 20 children in a 3-year birth cohort was conducted to investigate the prevalence of symptomatic and asymptomatic PCR-confirmed cryptosporidial diarrhea in children living in a semi-urban slum community in Vellore, India (Ajjampur, Sarkar, Sankaran, Kannan, Menon, Mulyil, Ward, & Kang, 2010). Stool samples were collected and tested every two weeks; 8% of stools were positive for *Cryptosporidum* species. Among the 20 children, there were 35 confirmed episodes of cryptosporidiosis and 40% of children had multiple episodes of infection during the study period. Long-term shedding oocysts was detected during both the asymptomatic period prior to an episode of diarrhea and following the resolution of symptoms, which has important implications for transmission in an urban slum setting with inadequate sanitation. Comparable study data are difficult to find for similar populations. The country-wide prevalence *Cryptosporidium* diarrhea in Malawi children under the age of 5 is estimated to be 10% and prevalence in a study at an urban and a rural site in the country was 5.9% (Morse, Nichols, Grimason, Campbell, Tembo, & Smith, 2007). *Cryptosporodium* infections from urban areas were predominantly caused by *C. parvum* (70%), although *C. hominis* was responsible for 64% of all infections (Morse et al., 2007).

A cross-sectional household study was undertaken in 2008 among urban slums in Gujarat, India to quantify the prevalence of intestinal parasitic infections as well as sanitation conditions (Shobha, Bithika, & Bhavesh, 2013). Overall prevalence of any intestinal parasitic infection was 15%. The majority of infections were protozoal in nature and only 25% of

infections were characterized by the presence of helminths, consistent with the findings of other studies in the region. Less than 4% of infections were polyparasitic. The response rate was poor for stool sample collection (less than 50% of individuals and households) and may introduce selection bias, which the authors suggest may have biased their findings toward the null.

A hospital-based laboratory surveillance study was conducted to investigate the prevalence of parasitic infections among the patients admitted with diarrhea to the Infectious Disease Hospital in Kolkata, India between November 2007 and October 2008 (Mukherjee, Chowdhury, Bhattacharyal, Ghosh, Rejendran, & Ganguly, 2009). Parasite prevalence was highest in preschool age children. *Giardia lamblia*, *Cryptosporidum* species, and *Entamoeba histolytica* were the organisms most commonly isolated from stool, and mixed infections with rotavirus, *Vibrio cholerae,* Shigella, and other pathogens were frequently reported. Importantly, slum areas were identified by GIS as being significantly associated with higher incidence of parasitic infection, lending credence to the relationship between the living conditions of slums and infection with intestinal parasites in India.

Additional water and sanitation-related illnesses. Surveillance was conducted between 2000 and 2001 for blood culture-confirmed typhoid fever in children living in Kamalapur, an urban slum in Dhaka, Bangladesh by the ICDDR, B research group (Brooks et al., 2009). Overall incidence was 3.9 episodes/1000 person years. Preschool children had the highest incidence compared to older individuals (18.7 episodes/ 1000 person-years vs 2.1 episodes/1000 person-years, respectively) and a relative risk 8.9 times that of older individuals. A follow-up study conducted between 2003 and 2004 in Kamalapur demonstrated that the incidence of typhoid fever (2.0 episodes/1000 person years) is higher than parathyphoid fever (0.4 episodes/1000 person years) in urban slum dwellers, and children less than 5 years of age had a relative risk 12-

fold higher than older individuals (Naheed et al., 2010). A multi-center surveillance study of non-typhoidal *Salmonella* also found the incidence of *S. typhi* to be very high in children in 5 sites in Asia, including urban slum sites in Kolkata, India and Karachi, Pakistan (Khan et al., 2010). Less than 1% of all Salmonella isolates (6) among all 5 sites were typed as non-typhi, while 475 were typed as *S. typhi*.

Kendall, LaRocque, Bui, Galloway, Ari, Goswami, Breiman, Luby, & Brooks (2010) examined the prevalence of leptospirosis in a poor urban Bangladeshi community (Kamalapur) using a combination of serologic tests and the presence of symptoms consistent with definite or probable infection. Febrile individuals were identified through community-based surveillance and paired sera were collected after illness onset to detect *Leptospira*-specific IgM. Previously unknown, the authors estimate that the disease prevalence in the community is in the range of 2% and 8% but explain that they faced a a number of challenges when diagnosing a largely undescribed disease with non-specific symptoms, but that their findings suggest leptospirosis, a rodent-borne illness, should be considered in the differential diagnosis of fever in urban slums.

Respiratory illnesses. The prevalence of TB in children and adults aged 15 and older was studied using a nationwide multi-stage cluster survey of 52,000 people at urban and rural sites across Bangladesh between 2007 and 2009 (Zaman, Hossain, Banu, Quaiyum, Barua, Salim, Begum, Islam, Ahmed, Rifat, Cooreman, Van Der Werf, Borgdorff, & Van Leth, 2012). There were 33 new smear-positive cases detected in the population during the study. The crude adjusted prevalence is 63.3/100 000 (95% CI 43.6–88.9) and the adjusted prevalence was 79.4/100 000 (95% CI 47.1–133.8), highest in adults over the age of 55 and lowest in young adults, and actually higher in rural areas than in urban areas. The authors suggest that recent health education and awareness interventions may have increased healthcare seeking behaviors

and contributed to the reduction seen in urban settings. Banu and colleagues (2013) conducted a cross-sectional, survey in an urban slum in Dhaka, Bangladesh between 2009 and 2010 and estimate the prevalence of TB in urban slums to be 253/100,000; by comparison the national TB prevalence survey found overall and urban rates to be far lower (79.4/100,000 and 51.1/100,000, respectively). The disparity between the figures likely illustrates the success of an active rather than passive case-finding approach to TB surveillance and control in a marginalized people group like an urban slum.

In 2009, the avian influenza surveillance program in Bangladesh detected H5N1 influenza in a 16 month old boy, causing grave concern about the pandemic potential for transmission in crowded urban areas (Brooks, Alamgir, Sultana, Islam, Rahman, Fry, Shu, Lindstrom, Nahar, Goswami, Haider, Nahar, Butler, Hancock, Donis, Davis, Zaman, Luby, Uyeki, & Rahman, 2009). This case illustrates the necessity of early warning programs and surveillance such as the one being used by ICDDR, B, whose program utilizes a combination of hospital-based and population-based surveillance; however, the authors warn that a limitation of their sampling frame is being unable to detect mild or asymptomatic cases. Thus, the true burden of this respiratory disease may be underestimated.

3.4 Burden of non-communicable disease in South Asian urban centers

Cardiovascular disease and modifiable risk factors. A cross-sectional study of 780 individuals living in Karachi, Pakistan was conducted between 2010 and 2011 to determine the prevalence of hypertension, obesity, diabetes, and coronary artery disease (Khan, Lotia-Farrukh, Khan, Siddiqui, Sajun, Malik, Burfat, Arshad, Codlin, Reininger, McCormick, Afridi, and Fisher-Hoch, 2013). Similar to what is known for other South Asian cities, greater more than

25% of participants were classified as overweight or obese, and the prevalence of hypertension was 18%; 8% of individuals were diabetic.

An Indian study comparing CVD risk factors among men from rural, urban slum, and urban middle class communities suggests that BMI and HDL are higher in urban areas than in rural, but that prevalence in urban slums falls in between their rural and urban middle class counterparts (Yajnik, Joglekar, Chinchwadkar, Sayyad, Deshpande, Naik, Nhat, Ganpule, Shetty, & Yudkin, 2013). Elderly people over the age of 60 (n=407) living in an urban slum in India reported a high prevalence of hypertension (30.7%) and diabetes (12%) (Thakur, Banerjee, & Nikumb, 2013).

To define mortality patterns in an urban slum in Kolkata, India, a verbal autopsy study was conducted for all deaths in a cohort of 63,788 residents (Kanungo, Tsuzuki, Deen, Lopez, Rajendran, Manna, Sur, Kim, Gupta, Ochiai, Ali, von Seidlein, Bhattacharyaa, and Clemens, 2010). Deaths were classified according to the *International classification of diseases, 10th edition.* Overall mortality was 6 deaths per 1000 person-years. Child deaths were classified as primarily infectious in nature, but deaths in adults were largely due to non-communicable causes, including cardiovascular diseases (36%) (Kanungo et al., 2010). Adult deaths in another verbal autopsy study in an urban slum in Islamabad, Pakistan showed deaths attributable to heart disease of 63.7% (Abbas, Alam, & Majid, 2011).

A chronic disease more commonly seen in children than adults, rheumatic heart disease, was found to be more common in rural Indian areas than in urban (4.8/1000 vs 1.9/1000, respectively) in a study conducted in Shimla between 1992-1993 (Thakur, Negi, Ahluwalia, & Vaidya, 1996).

Stroke. A recent review of stroke prevalence in South Asia illustrates the variability, imprecision, and incompleteness of collected data, with figures ranging from 44-843/100,000 in India to 500-2000/100,000 in Bangladesh, and no stroke prevalence studies have been conducted in Nepal (Prasad, Vibha, & Meenakshi, 2012). A 2008-2009 community-based stiudy was conducted in Pakistan to assess the burden of stroke and transient ischemic attack (TIA) in 545 adults 35 years of age and older living in an urban slum in Karachi (Kamal, Itrat, Murtaza, Khan, Rasheed, Ali, Akber, Akber, Iqbal, Shoukat, Majeed, and Saleheen, 2009).Stroke and TIA were assessed through questionnaire and neurological exam. Twenty percent of participants screened positive for stroke, and 10% had evidence of previous TIA. Females in this population were significantly more likely to have stroke or TIA than men (70%; p=0.001). Significant risk factors included hypertension, elevated blood glucose, and the use of chewing tobacco Hypertension was high for people who had experienced stroke or TIA (63.9%) and for people who had never experienced a CVD event (47.7%).

Incidence of stroke and TIA was assessed in a cross-sectional study in an urban slum in Karachi, Pakistan (Itrat, Ahmed, Khan, Muhammad, Thaver, Khowaja, Ali, Bawa, Rahat, & Kamal, 2011). Participants 35 years of age and older were selected by simple random sample (n=545) and interviewed using a standardized questionnaire tool for symptoms of stroke or TIA; Twenty-two percent of study participants (n=119) were found to have symptoms consistent with stroke or TIA, which the authors say is comparable to prevalence data on coronary artery disease in adult Pakistanis. Common risk factors included obesity (56.9%) and hypertension (52.1%). The odds of CVD increased in a dose-dependent manner as the presence of modifiable CVD risk factors in an individual increased from one (14.3%) up to five (86%).

Diabetes mellitus and modifiable risk factors. Recent estimates indicate that 41 million people in India have diabetes, and the prevalence of diabetes in India's urban population is twice as high as in rural areas (20% vs 10%) (Ramachandran and Snehakatha, 2009). A household survey study of the prevalence of diabetes and hypertension in an urban slum population in Kadugondanahalli, Bangalore City, India that was conducted between 2009 and 2010, based on self-reported survey data, had a much lower figure of 6.4% adults with diabetes and 10% with hypertension (Bhojani, Beerenahalli, Devadasan, Munegowda, Devadasan, Criel, and Kolsteren, 2013). An obvious limitation of self-reported data is the urban slum population's ignorance of chronic disease risk factors and thus a reporting bias towards the null (Kamal et al., 2013).

An older household and clinic-based study of diabetes and CVD risk factors that was conducted in India diagnosed diabetes in 10% of the 540 participants and classified 15.6% of women as and 13.3% of men as obese (Misra, Pandley, Devi, Sharma, Vikram, & Khanna, 2001). Variability in reported prevalences of diabetes within urban areas is probably due in part to the great differences in study design and indicators and tools used for diagnosis, but does seem to be consistently higher in urban populations than in rural (Misra et al., 2001; Ramachandran and Snehakatha, 2009; Kamal et al., 2013).

Chapter 4: Discussion, Recommendations, and Conclusions

4.1 Discussion

Limitations. Many of the relevant studies that have been conducted exploring the relationship between urbanization and the burden of disease have inherent limitations and biases due to study design, differences in study quality and scope, and limited generalizability. Randomized controlled trials are often considered the gold standard study design in evaluating

public health interventions, but often do not have utility for exploring non-intervention-based research questions such as measuring disease burdens and risk factors. All studies in this review were observational cross-sectional and cohort studies, and the measures of association evaluated were incidence and prevalence rates. Relatively few cross-sectional studies were population-based (mostly surveillance studies conducted by KEMRI/CDC in Nairobi, Kenya) which creates challenges when trying to apply a study's narrow result to a more general population group of interest. Furthermore, there was great variation in the power and rigor of study designs which may impact both the ability to detect true associations and to have the internal and external validity to generalize results to other populations. Some studies included as few as 20 children and others included thousands and tens of thousands.

Substantial differences exist among the populations studied, the case definitions applied, and the potential for the introduction of bias. The epidemiological transition is thought to be occurring at different rates in different populations, which can make it challenging to confidently compare burdens of disease in different countries or even within a country (State of the World Population, 2007). Researchers also consistently cited studies' use of different case definitions (such as diarrheal illness and ALRI) as a significant obstacle when comparing their findings to the existing literature, often resulting in indirect and excepted comparisons being made (van de Vijver et al., 2013). Results from different types of surveillance are also not directly comparable; cases detected by hospital or clinic-based surveillance tends to detect more severe disease that resulted in healthcare-seeking behavior (and also might miss cases where health care utilization is low), while household surveys may find a broad spectrum of disease presentations. Finally, the potential for bias was treated differently by researchers and may make interpretation of results challenging. Feikin et al. (2011) addressed the potential for recall bias in reporting of episodes of

diarrheal illness in children under the age of 5 by reducing the recall period from two weeks to the preceding three day period. By contrast, Govender et al. (2005) did not address the possibility of similar recall bias in a similar study of diarrheal incidence in young children.

It is important to address certain biases introduced by the inclusion and exclusion criteria used in this review. Excluding articles not published in English was necessary due to the language abilities of the reviewer; although non-English articles published in regional journals tend to include less dramatic results than would be found in an international journal with wider readership and a greater impact factor, exclusion may have inadvertently resulted in the omission of relevant studies with novel, confirmatory, or contrasting results.

Gaps in Knowledge. Most studies of urbanization-associated disease burdens and the epidemiological transition in Africa and Asia have been concentrated in very few countries within enormous and populous regions. Many studies about infectious diseases in Africa have been conducted in the Kibera and Lwak communities of Kenya by researchers associated with the KEMRI/CDC group. Similarly studies from Asia almost exclusively describe disease prevalence in India, Pakistan, and Bangladesh, including the ICCDR,B. Surveillance is essential for future public health planning and wise resource allocation, yet there are other countries with substantial and growing urban areas where very little is known about the burden of diseases. Because the epidemiological transition is occurring at different rates in different countries, data collected in one country may not be sufficient or adequate to describe the epidemiology in ways that are meaningful or generalizable to another community.

One billion people live in urban slums (State of the World's Population, 2007). The magnitude of the social problem of massive urbanization of poverty is undeniable and vast, yet

number of researchers and institutions devoted to the subject does not seem adequate. In general, studies seem to be performed independently of one another and without much coordination between different research groups, resulting in duplication and discordance that does little to contribute to the solution. No recent studies have been published concerning RHD in Africa in urban populations, and much of the existing literature is not directly comparable because the data are aggregated or did not study urban slum populations. Despite decades of recommendations for future studies which adequately disaggregate health outcomes at the intra-urban level, the quantity, quality, and coverage of such data remains sparse and understudied.

4.2 Recommendations

Rapid urbanization is projected to continue and the strain beyond capacity will continue to build. The issues encompassed by urbanization, poverty, and health are vast and dynamic. No single, isolated solution can expect to be sufficient, but a response that is as multi-sectoral and rapidly-changing as the problem itself has a greater likelihood of success. The future of public health planning and action should be intentional and flexible in anticipation of these challenges.

Implement traditional, evidence-based public health interventions to improve health outcomes. Traditional public health strategies often include immunizations, nutrition and chemotherapy programs, disease surveillance, improved water, sanitation, and hygiene, and a variety of community outreach and health education programs. In some situations, evidence-based public health interventions tailored to meet the specific needs of communities can have significant implications for preventing immediate and short-term morbidity and mortality (Patel & Burke, 2009; Khan et al., 2013).

Immunizations are classic, effective and efficient tools for reducing morbidity and mortality in vulnerable populations. Brooks et al. (2005) recommended expanding and targeting a typhoid immunization program to children in their first year of life in Dhaka, Bangladesh to reduce the burden of disease experienced by preschool-aged children in an urban slum. Children 2-4 years of age in this population have a disease risk 9 times higher than older children, and vaccination of at-risk infants would be expected to reduce the burden of typhoid in older children even if the urban risk factors for transmission, poor water and sanitation infrastructure, remain unchanged. Breiman et al. (2012) similarly discusses the potential benefits of geographic targeting of immunization programs like typhoid to affected population groups such as young children in urban slums.

The integration of anti-helminth and micronutrient feeding programs should be considered in communities that experience soil-transmitted infections to address the potential for chronic malnutrition, anemia, micronutrient deficiencies, and development delays (Suchdev et al., 2014; Neervoort, von Rosenthal, Bongers, Demetriades, Shacola, & Wolffers, 2013).

Community-based health education programs may be effective for combating infectious and non-communicable diseases, including promoting handwashing (Langford, Lunn, & Panter-Brick, 2011), diabetes management (Ramachandran et al., 2009), and CVD risk factor awareness and reduction (Kamal et al., 2009; Joshi, Mehta, Grover, Talati, Malotra, & Puricelli Perin, 2013).

Form multi-sectoral partnerships and enact innovative policies and programs to challenge underlying social norms that perpetuate the existence of urban slums. Traditional public health measures alone will not be sufficient to affect meaningful, long-term

transformation of the communities that concentrate urban poverty because they are unable to challenge the underlying factors sustaining slum growth, including inadequate job opportunities, corruption and poor governance, social problems and marginalization, barriers to economic development, infrastructure, service delivery, and more (Mutatkar et al., 1995; Moore, Gould, & Keary, 2003; Challenge of Slums, 2003). Partnerships and collaboration among many seemingly disparate sectors will be necessary for developing innovative solutions.

The acutely informal and often illegal nature of slum housing creates great challenges for being able to make improvements and upgrades (State of the World's Cities, 2013; Godfrey and Julien, 2005). Secure tenure would stimulate the local economy because it encourages people to invest in improving their homes. Programs that permit land ownership would also help to lift people out of the cycle of poverty.

Preventing rural to urban migration as a means of reducing the population influx has been proposed by some but rejected by others as impractical and illegitimate—mass migration to urban sites is happening and must be acknowledged and addressed (Godfrey and Julien, 2005; State of the World's Population, 2007). One alternative to this might be the development of businesses in new areas to increase rural migration to a new site not yet clouded with the complex constraints of existing cities, which would benefit not only the individual searching for opportunities but also potentially reduce some of the ills of urbanization by enabling better and proactive urban planning to take place.

Scale up the Urban HEART tool as a framework for disaggregated data collection and dissemination, program implementation, and monitoring and evaluation. The critical tenets of public health surveillance include systematic collection, analysis, and dissemination of

health data to inform timely action, yet surveillance for health outcomes in urban slums is, thus far, anything but systematic, comprehensive, or timely, and the lack of clear evidence severely hinders program design and resource allocation (Patel & Burke, 2009). After a decade of researcher recommendations, global summits, and intercontinental action plans discussing the great need for comparable, accessible, disaggregated urban data, the World Health Organization has produced a remarkably holistic framework known as the Urban Health Equity Assessment and Response Tool (Urban HEART), to be used by countries and cities for tracking and addressing urban health inequities ("Urban Health Equity Assessment and Response Tool--Urban HEART," 2014). The framework is touted as being user-friendly while simultaneously including many sectors and stakeholders in the planning process, and emphasizes the use of data collection through existing sources as a means of maintaining feasibility and sustainability. Countries, cities, and communities should be engaged throughout the planning and decision-making process and empowered to take ownership of the problem. Using this framework will help to empower communities to act as change agents and advocates of action**.**

The six steps the Urban HEART tool promotes include building an inclusive team of stakeholders and partners, defining a local set of standardized indicators and setting benchmarks, accessing relevant data from existing datasets whenever possible, analyzing and organizing data into charts and tables, identifying gaps and discussing and prioritizing health issues, and deciding on a plan of action to address priority issues. The program was pilot-tested in 2008 in 17 cities in 10 countries and was scaled up between 2010 and 2013 to 50 cities in 35 countries; 7 countries prepared evaluation reports between 2011 and 2012 (Figure 3). An expert consultation and evaluation conference was held in Kobe, Japan in November 2013 seeking recommendations and input for updating a second version of the tool which is expected to be ready for release later this

year. Key recommendations were increasing partnerships with the UN and other agencies, increased community advocacy for the tool and engagement of the private sectors and Ministry of Health officials ("Urban Health Equity Assessment and Response Tool--Urban HEART," 2014).

Scaling up this tool in more cities will be an excellent way to tailor programs to meet a community's dynamic and unique needs while also maintaining a central management system to ensure greater cross-talk among researchers from different sectors. Collecting data for standardized indicators at the neighborhood level and disseminating it to key stakeholders empowers the community and directs timely, evidence based public health action.

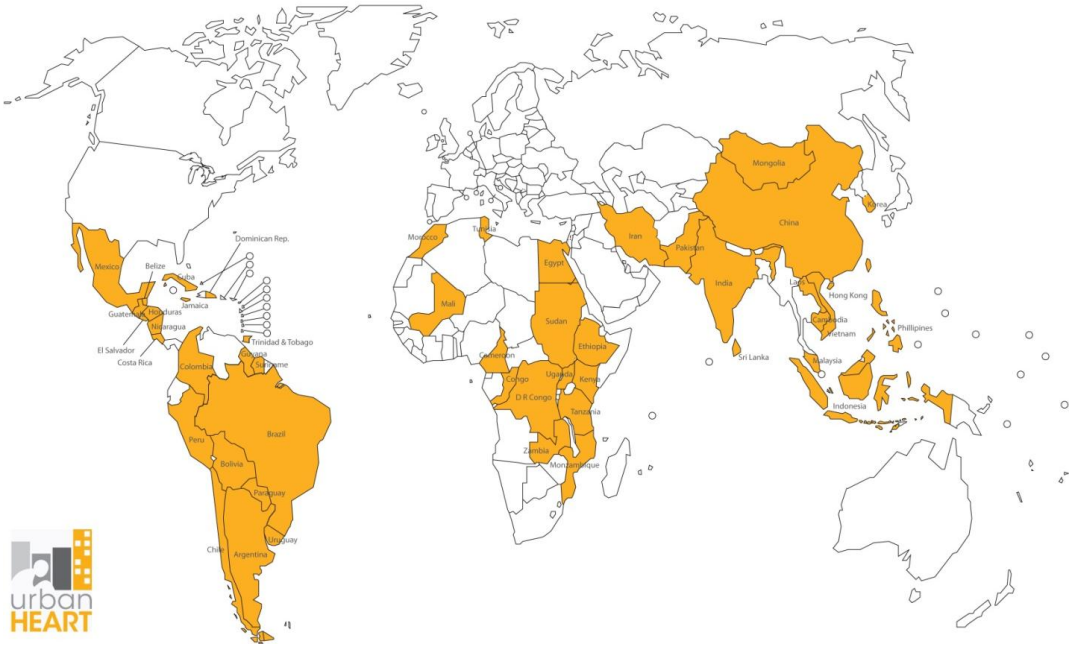

Figure 3. Countries who have built capacity on Urban HEART, 2008-2011. (Urban HEART, 2014)

Conduct future research in underrepresented areas with greater cohesiveness and standardization. There are a number of areas of research for which data are not recent or may not exist at all, and would be important for planning. Aggregate data can be misleading because

of intra-urban differences in disease burden, yet many studies do not focus on urban slum populations. Some of these areas include TB incidence and prevalence in urban and rural populations, risk factors for respiratory infections, emerging urban diseases such as leptospirosis, and chronic diseases such as diabetes disaggregated at the urban slum level. Studies that consider the interactions between infectious and non-communicable diseases in urban slum populations are also of great value going forward in a world where this "double burden" affects more and citizens.

Data are missing for many countries and cities which lack well-established disease surveillance programs. Any future research should be conducted where there are important gaps in knowledge such as these, but it is critical that greater consideration be given to the use of more standardized indicators, case definitions, and study designs in order to generate data which are more comparable and relevant than most existing data.

4.3 Conclusions

Unprecedented rates of urban growth have outpaced many cities' capacities to provide adequate housing, job opportunities, economic stability, and basic services to their citizens, resulting in the formation of slums, informal settlements, and shantytowns that can become hubs of poverty, marginalization, and neglect. Urbanization increases the burden of many diseases, and often infectious and non-communicable diseases both contribute to significant morbidity and mortality in the same communities. Studies and interventions thus far have revealed that there are many gaps in understanding of the prevalence of diseases in urban slums, including in what urban centers the burden is greatest. Future research should be done in underrepresented areas where the need is greatest, and studies should be undertaken with greater standardization of case

definitions and indicators to facilitate greater utility and generalizability of results. Rigorous impact evaluations are not always conducted, and even when evaluations are conducted it may not be possible to detect true changes in outcome attributable to a program if there is the potential for a spillover effect.

Urbanization-attributable disease is a complex and multi-sectoral issue and will require prompt and collective action to be effectively addressed, but it is a challenge permeated with optimism that cities can be their own change agents. UN-HABITAT stated it perhaps most eloquently in their 2007 report on the State of the World Population: "Cities concentrate poverty, but they also represent the best hope of escaping it."A grassroots approach to activism, collaboration and partnerships is critical. Implementing interventions that comprehensively address the public health problems from both traditional and innovative perspectives is imperative to reduce morbidity and mortality in the short term as well as challenging the social norms that perpetuate the cycle of poverty and slum dwelling.

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Appendix A

Number and percent of articles reviewed by country and region

Region	Country	Number of Articles (% of region)
Africa	Benin	1 (3%)
	Cameroon	1 (3%)
	Democratic Republic of Congo	1 (3%)
	Ghana	1 (3%)
	Kenya	18 (57%)
	Nigeria	2 (6%)
	Senegal	1 (3%)
	South Africa	3 (10%)
	Tanzania	1 (3%)
	Uganda	2 (6%)
	TOTAL	**31**
South Asia	Bangladesh	7 (23%)
	India	15 (50%)
	Pakistan	8 (27%)
	TOTAL	**30**