



Health & Demographic Surveillance System Profile

Health & Demographic Surveillance System Profile: The Nairobi Urban Health and Demographic Surveillance System (NUHDSS)

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Abstract

The Nairobi Urban Health and Demographic Surveillance System (NUHDSS) was the first urban-based longitudinal health and demographic surveillance platform in sub-Saharan Africa (SSA). The NUHDSS was established in 2002 to provide a platform to investigate the long-term social, economic and health consequences of urban residence, and to serve as a primary research tool for intervention and impact evaluation studies focusing on the needs of the urban poor in SSA. Since its inception, the NUHDSS has successfully followed every year a population of about 65 000 individuals in 24 000 households in two slum communities—Korogocho and Viwandani—in Nairobi, Kenya. Data collected include key demographic and health information (births, deaths including verbal autopsy, in- and out-migration, immunization) and other information that characterizes living conditions in the slums (livelihood opportunities, household amenities and possessions, type of housing etc.). In addition to the routine data, it has provided a robust platform for nesting several studies examining the challenges of rapid urbanization in SSA and associated health and poverty dynamics. NUHDSS data are shared through internal and external collaborations, in accordance with the Centre's guidelines for publications, data sharing.

Key Messages

- The Nairobi Urban HDSS was the first ever urban, slum-based HDSS in Africa. The population in the slums is highly mobile but, at the same time, the slums are long-term homes for many people.
- Although childhood mortality is declining, under-fives bear the highest disease burden, with diarrhoea and pneumonia being the leading causes of child deaths. Maternal mortality is much higher in the two slums than the national average.
- Injuries contribute substantially to the high level of mortality attributable to non-communicable diseases in the two communities.
- Evidence from NUHDSS and nested studies has increasingly become a major input in policy making and programme implementation in Kenya and elsewhere.

Why was NUHDSS set up?

Nairobi, Kenya's capital city, is a typical sub-Saharan Africa (SSA) urban centre characterized by population explosion amid growing and chronic urban poverty and declining livelihood opportunities in the city. In the past 50 years, the population of Nairobi has grown almost 12-fold, from around 293 000 inhabitants in 1960 to about 3.4 million in 2010. Yet, over the years, little has changed in terms of infrastructure development, which has led to the majority of residents—currently estimated at 60–70% of the city's population—to live in informal settlements or slum-like conditions.^{1,2} Evidence from the first ever Nairobi Cross-sectional Slums Survey (NCSS) conducted in the city by the African Population and Health Research Centre (APHRC) in 2000 revealed that slum residents have the worst health outcomes of any group in Kenya (including rural residents);^{2–6} they have limited access to basic facilities such as water and sanitation, or opportunities for life such as education and employment; and they endure the complete absence of the public sector and law enforcement agencies in their daily lives. These conditions not only expose slum residents to poor health outcomes but also foster violence and social unrest, which ultimately can easily spread beyond a single neighbourhood to endanger most residents of the city.⁷

It was against this background that the APHRC established the Nairobi Urban Health and Demographic Surveillance System (NUHDSS) in 2002 in two slum communities (Korogocho and Viwandani) in Nairobi city. The main goal of the NUHDSS was to provide a platform to investigate the long-term social, economic and health consequences of urban residence, and to serve as a primary research tool for intervention and impact evaluation studies focusing on the needs of the urban poor in SSA.

The NUHDSS has been granted ethical clearance by the Ethical Review Board of the Kenya Medical Research Institute (KEMRI).

What does it cover now?

The NUHDSS focused not just on demographic events but also on other information that could help explain the linkages between urbanization, poverty and health dynamics in the slum settlements. Most recently, the NUHDSS started collecting information on fertility preferences and contraceptive use among women aged 15–49 years.

Where is the HDSS area?

The NUHDSS is located in two Nairobi slums—Korogocho and Viwandani [also referred to as the

demographic surveillance area (DSA)] that are located about 7 km from each other (Map 1).

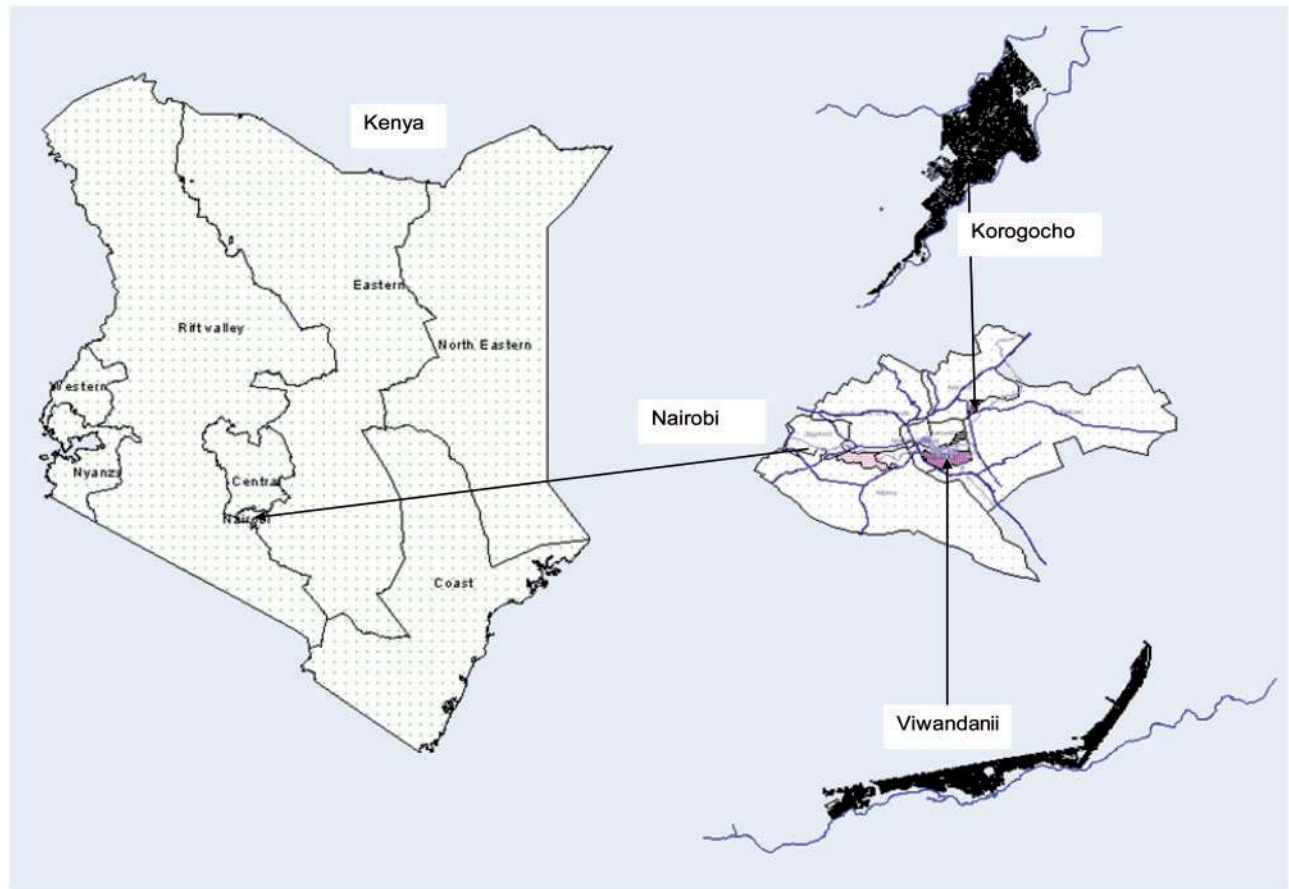
Korogocho, the fourth largest informal settlement in Nairobi, was developed on land originally owned by an individual called Baba Dogo, and on what was left by the City Council as a reserve land on the banks of the Nairobi and Gitathuru rivers. It covers an area of about 0.97 km² and is located north-east of Nairobi about 12 km from the Nairobi Central Business District (CBD). Structures in Korogocho mostly have mud and timber walls with waste tin cans as roofing material. The houses are built in rows with an average of six dwelling units (rentable rooms) per structure.

Korogocho is one of the most congested slum areas of Nairobi, with over 250 dwelling units per hectare (Map 2). The Nairobi Refuse Dump site is situated to the east and south-east of the slum. Korogocho has a stable and settled population, with many of the residents having lived in the area for many years.⁸ On average, a household with an average size of about three persons occupies about one rentable room.

Viwandani is located just 7 km from the CBD, and was established in 1973 on land that had been left by the City Council as a reserve area on the bank of Ngong River (Map 3). Many of its residents are youthful and highly mobile, working or seeking jobs within the nearby industrial area. Those born in the area represent only 5% of its population.⁸ The Ngong River, which is heavily polluted by industrial waste from the neighbouring industries, is situated to the south of the settlement. Structures in Viwandani on the most part have iron sheet and tin walls with iron sheet roofs. Houses are built in rows with an average of six rentable rooms per structure.

Who is covered by NUHDSS and how often have they been followed up?

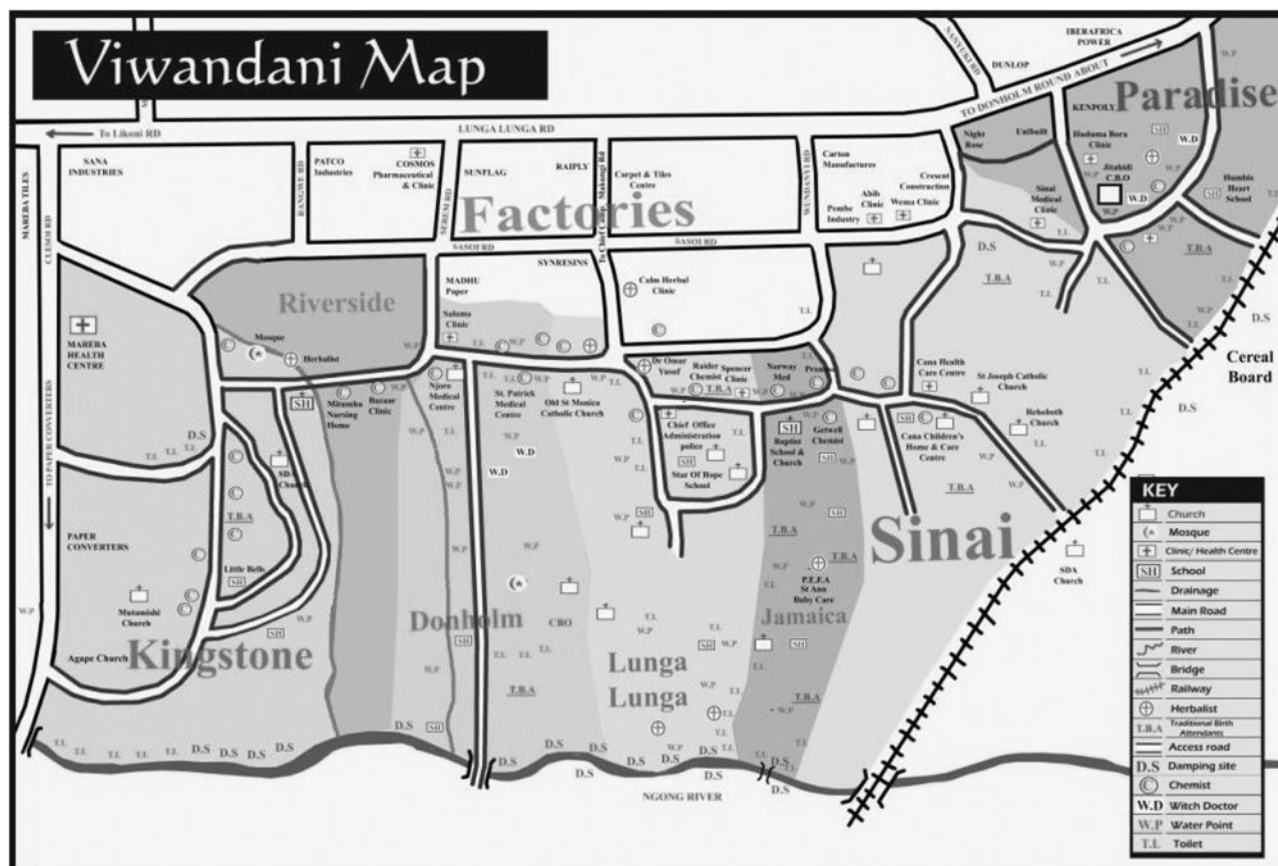
The NUHDSS started as a pilot study in 2000 but was subsequently scaled up in August 2002 to cover Korogocho and Viwandani which are two of Nairobi's largest informal settlements. The baseline census of all residents, conducted in August 2002, indicated that about 60 000 people were living in about 23 000 households in the DSA, with Viwandani being the most populous of the two slums (54%, vs 46% in Korogocho). As of 31 December 2012, the study population stood at 63 639 individuals living in 25 793 households, with Viwandani still being the most populous (57%, vs 43% in Korogocho). During the initial census, all residential housing units and households in the DSA were also marked with unique identification numbers.



Map 1. Location of the Nairobi Urban Health and Demographic Surveillance System.



Map 2. Map of Korogocho.



Map 3. Map of Viwandani.

After the initial census, field interviewers visit every household living in the study area every 4 months, and collect information on key demographic and health events. In addition, the interviewers collect information on people who have moved and spent at least 4 months prior to the time of interview in the household; these become new residents/in-migrants into the study area. A resident is defined as an individual who has spent at least 4 months continuously within a rentable housing unit in the study area and may or may not have slept in that unit the previous night before the date of interview, whereas a household is defined as a group of people who eat from the same pot. An update of the residential status of each numbered housing unit is also done. New housing units are also numbered and added to the master list of housing units located in the study area.

Data show that, in 2012, 35% of the female population and 29% of the male population were aged less than 15 years; those aged 15–64 years constituted 64% and 70% among females and males, respectively; those aged 65 years and above made up 1% of the total NUHDSS population (Figure 1). Notable differences are seen between the two slums in population structure by age and by sex. Viwandani’s population has many more males aged 15–64 than Korogocho, whereas Korogocho has a slightly larger share of children aged

0–4 years (Figure 2). In fact, Korogocho has a more stable population: only about a third of females (36%) and of males (36%) are aged 20–39, and older people aged 65 and above represent about 2% of male and female residents in Korogocho. On the other hand, about half of males (52%) and of females (51%) are aged 20–39 in Viwandani and less than 1% of male and female residents in Viwandani are aged over 65. These figures confirm that, compared with Korogocho, Viwandani attracts a higher flow of young people coming to the city in search of job opportunities in the nearby industries.



Photo 1. View of Korogocho slum.



Photo 2. Field enumerator interviewing an HDSS resident.

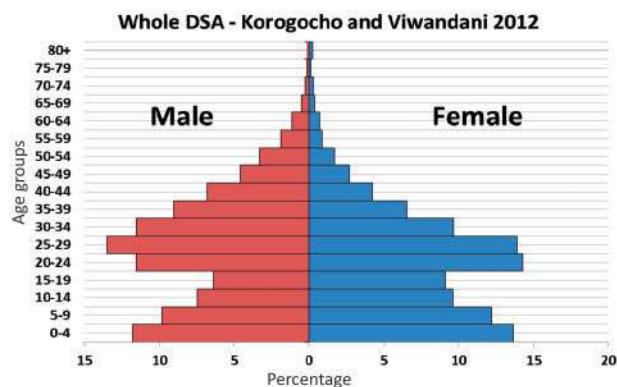


Figure 1. Population pyramid of the Nairobi HDSS in 2003 and in 2012.

What has been measured and how have the HDSS databases been constructed?

Key information collected

A number of key health and demographic events are captured in the NUHDSS every 4 months (see Table 1).

Births

Only births that occur to mothers who are residents in the NUHDSS are captured, using a pregnancy outcome questionnaire. Details regarding the circumstances under which the birth occurred and some information related to antenatal care the mother received during the pregnancy are also captured. In 2012, the total fertility rate was estimated to be 2.7 births per woman, with a crude birth rate of about 28.9 per 1000 person-years.

Deaths

Deaths that occur to NUHDSS residents are captured using the Events History/Status Update questionnaire. Detailed information regarding the circumstances surrounding the death is captured using the Verbal Autopsy (VA) questionnaire. In total, verbal autopsies were undertaken for 87% of all deaths recorded between 2003 and 2012. The rest was

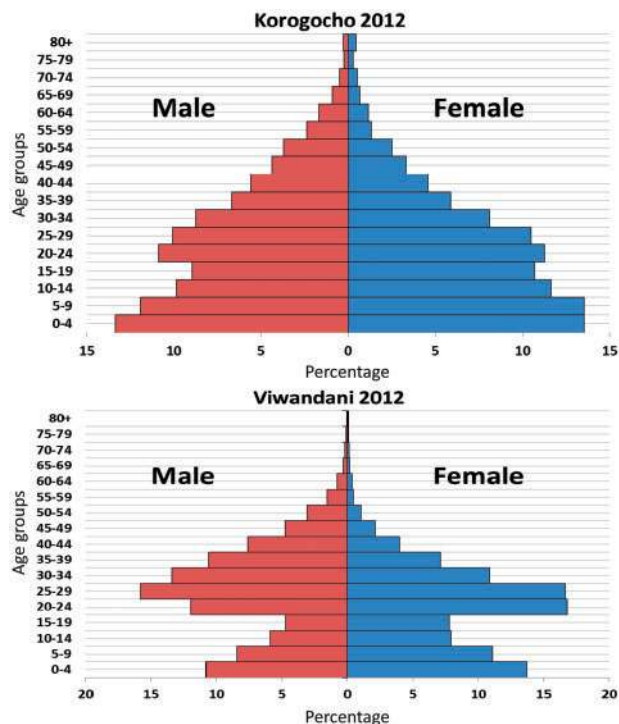


Figure 2. Population pyramids of (a) Korogocho and (b) Viwandani in 2012.

not done mainly because it was not possible to find a credible household member, close relative or neighbour for the interview. The highest completion rate of VAs was observed in 2012 (97%), whereas the lowest was observed in 2009 (64%). In addition, the diagnosis was successfully generated for 91% of all completed VAs during the period 2003–12, with the lowest success rate observed in 2004 (81%) and the highest in 2006 (96%). In 2012, the crude death rate was estimated at about 6.2 per 1000 person-years.

In- and out-migrations

Tracking details of migration patterns is key in the two slums that are characterized by high internal and external movements. Migration status within the NUHDSS area is determined using the threshold period of 120 days. This implies that for one to be considered as an in-migrant, he/she has to have lived in the DSA for at least 120 days, whereas a resident becomes an out-migrant if he/she has stayed away from the DSA for at least 120 days. Data on out-migration are often collected from proxy respondents, given that the interview takes place after the migrant has left the DSA. The NUHDSS also considers internal mobility or changes of residence within the DSA.

Other information

The NUHDSS collects detailed information on housing characteristics, possessions and amenities, and household

Table 1. Information collected at each re-enumeration round of the NUHDSS

Subject	Information
Building unit/ structure-level information	Number of structures/building units
	Status of the structure (demolished, merged, live-in unit)
	Unique identification numbers (IDs) for all structures and all rentable rooms within structures; define their uses (dwelling/sleeping rooms, schools, toilets, churches, mosques, water points, business rooms, etc.). The IDs are then painted on the door frame or (quasi-) permanent sections of the building. Status of the structure (demolished, merged, live-in unit) is also registered.
Household	Household head name; household amenities/possessions, housing conditions, livelihoods, relationships between members Household head name
Individual	Individuals names (3), sex, date of birth, ethnic group, religion, marital status; employment status, education (5–24 years old), mother's details; father's details Residents update of residency status (resident, died, out-migrated)
Births	Date and place of birth Names (3) and sex of child Mother's personal identity number and 3 names (link); father's details
Deaths	Deaths: date of death, verbal autopsy Place of death
Vaccination	Immunization status of all under-five children: date of vaccination, type of vaccine received, main reason for not being given a vaccine, vaccination records
In-migration	Date of in-migration; reason for in-migration; education (5–24 years old); names (3), sex and date of birth of in-migrant; mother and father's details Origin of migration episode Previous residence within the HDSS
Out-migration	Date of out-migration; reasons for out-migration Destination of migration episode
Entry	Date of entry Original room from which resident moved
Exit	Date of exit Room to which the resident moved
Pregnancy and birth registration	Pregnancy outcomes of existing pregnancy records in the community: live birth, multiple birth, still-birth, miscarriage, maternal death Additional data on pregnancies include: birth history, pregnancy duration, date of delivery or pregnancy end date, place of delivery and use of health facility, number of fetuses and the outcomes. In addition, the form includes questions on the child and his/her father's characteristics if the outcome is a live birth

livelihoods and, at individual level, on: education, marriage, employment status, pregnancy outcomes, vaccination coverage, episodes of morbidity and health-seeking behaviour (see Table 1). Information on household characteristics and livelihoods are collected once a year. In 2012, the NUHDSS started collecting information on fertility preferences and contraceptive use among women aged 15–49, to identify fertility motivations and challenges faced by the urban poor in access to and use of basic the Family Planning/Reproductive Health services.

Databases

A relational database designed using Microsoft SQL Server and Visual Basic.Net is used to process the NUHDSS data. Information related to each component of the NUHDSS conceptual framework (individual characteristics, demographic events or behaviours, household characteristics etc.) are included in one table. To ensure high quality data, the NUHDSS has developed several data-quality enhancing procedures from the data collection to data cleaning through data entry, analysis and storage. Strategies used include refresher training before each round of the survey, close supervision of fieldworkers, spot checks, checking of all completed questionnaires for errors/inconsistencies and use of Amendment/Update forms to report corrections to mistakes that were made in previous rounds. Other key activities include checking the completeness of the data, pinpointing, documenting and correcting unexpected or out-of-range values, basic analysis for validation checks, merging files, and data documentation. Cleaned analytical files are subsequently posted on the internal server for use by researchers.

Key findings and Publications

A number of scientific papers have been produced and published in peer-reviewed journals using data from the NUHDSS platform and studies nested in its infrastructure. Of the nearly 60 peer-reviewed publications produced by APHRC researchers and their partners in 2011, more than half of these derived from the NUHDSS and nested datasets, including a special issue in the *Journal of Urban Health*. Table 2 summarizes some key health and demographic indicators of the NUHDSS.

Socio-demographic characteristics of the slum residents

In 2012, the sex ratio (including children) was 130 males to 100 females but with striking differences by age groups and between the two slum areas (Korogocho and

Viwandani). Analysis by age shows that overall there are more females than males in age groups 0–14 and 15–39 (sex ratio of 82 and 97, respectively), whereas the reverse is observed in age groups 40–59 and 60 and above (sex ratio of 175 and 128, respectively) (Table 3). The same trend is observed in each slum area. However, the excess number of males for those aged at least 40 is more pronounced in Viwandani. This is probably an indication of the higher in- and out-migration among active males in search of jobs in this slum which is close to the industrial area, although there is a higher circulation of women in both slums.⁹ Indeed, in Korogocho there are 136 males for 100 females among those aged 40–59 and 115 males for 100 females among those aged 60 years and above, whereas the corresponding figures are 225 for those aged 40–59 and 216 for those aged 60 years and above in Viwandani. On the other hand, the excess number of females among those aged less than 14 is more pronounced in Viwandani. A further examination of the data shows that there are unusually more girls in Viwandani in each 5-year age group until age 25: the sex ratios range from 60 among the 15–19 group to 79 among 0–4 group as compared with a range of 83 among the 15–19 group to 99 among the 0–4 group in Korogocho (data not shown). These trends are probably related to differences in migration patterns between the two slums; however there is need for further investigation. Overall, the Total Fertility Rate

(TFR) in the NUHDSS stands at about 3.1 children per woman between 2003 and 2012, which is higher than the TFR for Nairobi (2.8) but lower than the national level (4.6) as measured by Kenya Demographic and Health Surveys (KDHS) 2003 and 2008–09.¹⁰

Findings show that the majority of the slum residents were born outside Nairobi city, to which they in-migrated from rural areas in search of better livelihood opportunities. There is considerable in- and out-migration of the population.⁹ Between 2003 and 2012, on average, 25.8% of people migrated into the two slums every year whereas about 22.5% moved out of the two areas. NUHDSS data also demonstrate higher intensity of female migration as compared with males, and that females are increasingly contributing to the growth of the slum population through in-migration.

Analysis of NUHDSS data also shows that most of the households in the two slums are food-insecure; only about 20% of them are considered as food-secure and nearly half of them are 'food-insecure with both adult and child hunger'.¹¹ Households whose head has a low income, is female, is not educated, is a recent migrant or who has both children under 11 and adults aged 50 or above are more likely to be food insecure.

Child health in the two slums

Data show that childhood mortality is declining in the two slums, which is consistent with data from the last two Kenya DHSs.⁸ Further investigation is needed to shed light on the drivers of improvement in child survival in these communities, given the very low levels of childhood immunization.¹²

Findings on child mortality between 2003 and 2007 indicate that mortality is higher among children born in the slum settlements as compared with those born outside slums.¹³ Among slum-born children, mortality is highest among those whose mothers were pregnant while in-migrating into the slums. In fact, the risk of dying is about two times higher among children born within 8 months of their mother's migration into the slums. These

Table 2. Demographic characteristics of the NUHDSS (2003–12)

Indicator	Value
Total resident population (Annual average person-years)	61612
Male:female ratio	1.3
Crude birth rate/1000 person-years	33.8
Crude death rate/1000 person-years	8.1
Crude out-migration rate/1000 person-years	258
Crude in-migration rate/1000 person-years	225
Total fertility rate	3.1
Infant mortality rate/1000 person-years	52.6
Under 5 mortality rate/1000 person-years	16.88

Table 3. Sex ratio (male to female) by age group in Korogocho and Viwandani

Age groups	Sex Ratio			% of total NUHDSS population	
	Korogocho	Viwandani	Total	Female	Male
0–14	90.7	77.0	82.3	35.4	29.1
15–39	97.6	95.5	97.4	53.4	52.0
40–59	136.0	224.9	175.4	9.5	16.6
60+	115.0	215.8	127.8	1.7	2.2
Total	–	–	–	100.0	100.0

results indicate huge health inequities within these already marginalized groups, suggesting that children of recent migrants who are most exposed to slum health hazards need be targeted by appropriate health policies.

Analysis of data on children, collected between 2006 and 2008, shows that 60% of children aged 18–20 months were found to be stunted and about a quarter of them (23%) were severely stunted.¹⁴ This suggests that children's nutritional status should be given priority when it comes to improving child survival in the slums. Under-fives have the highest mortality burden, mostly due to diarrhoea and pneumonia.¹⁵ Other evidence shows that under-five mortality is seasonal in the two slums, with the death rate being two times higher during the second quarter of the year.¹⁶ In particular, under-five mortality due to pneumonia in the two slums is higher during the rainy season in April–June that also corresponds to the start of the cold season in Nairobi.¹⁷

Analysis of the birth spacing–child survival relationship indicates that early childhood and infant mortality risks are at least two times higher when the preceding birth interval is less than 18 months as compared with an interval of 36 months or longer.¹⁸

Adult health in the two slums

The patterns of mortality as determined using InterVA modelling indicates a high burden of infectious diseases in the two slums, including HIV/AIDS, tuberculosis and pneumonia.¹⁹ Maternal mortality ratio is estimated to be 709 per 100 000 live births in the two slums, which is much higher than the national average.²¹ Unsafe abortion and limited access to quality delivery services are the causes of one-third of these deaths. About 7 in 10 deliveries occur in health facilities, but many of these are of very poor quality, without basic equipment or qualified health-care providers, generally unlicensed and unregulated.⁶ Unintended pregnancy is high in the two slums as for 50% of women who delivered in the slums, pregnancy was either unwanted or mistimed.

Analysis of causes of deaths reveals that injuries contributed substantially to the high level of mortality attributable to non-communicable diseases in the two communities.²¹ Firearm injuries (23%) and road traffic accidents (22%) lead to deaths due to injuries and 15% of injuries are due to consumption of illicit brews. Injuries are often intentional (51%); 9 out of 10 intentional injuries are homicides and the rest are suicides.

Future analysis plans

The NUHDSS team plans to develop a comprehensive report on health, socioeconomic and demographic

indicators, showing levels and trends of these indicators in the two slums over the period 2003–13 and comparing them with indicators from the most recent other data sources in the country. In combination with several HDSSs in the INDEPTH network, researchers from the NUHDSS will be involved in developing scientific papers on the linkages between migration and adult mortality. Also, the NUHDSS data will be triangulated with data from three other HDSSs in Kenya to generate evidence on mortality and burden of diseases that will help the national and county governments develop the most appropriate policies and actions towards improving their population's health. Investigations of non-communicable diseases will also feature prominently in future analyses.

What are the main strengths and weaknesses?

Key NUHDSS strengths

The NUHDSS is an effective research platform

The NUHDSS has been an effective and productive research platform and central to APHRC's efforts to find cost-effective and sustainable strategies to address the deteriorating living conditions of poor urban populations in Kenya and across SSA. It has been a unique and pioneering effort at longitudinal data collection in urban slums, with its main strength being its potential to shed light on the drivers of health and demographic behaviours among the urban poor.

Through the NUHDSS and the evidence it provides on the causal linkages between urbanization, poverty and health, as well as other issues such as education, HIV/AIDS and non-communicable diseases in urban slums, APHRC has positioned itself, over the past decade, at the forefront of research on clarifying urbanization and its consequences on health and socioeconomic outcomes.

The NUHDSS has also supported the research career development of several junior researchers, including two Wellcome Trust-funded research training fellowships, and about twenty Masters and PhD theses.

The NUHDSS significantly contributed to policies and programmes in Kenya and in SSA in general

Findings from the NUHDSS and nested studies have been influential and extensively used in policy and programme discourses by donors and international agencies both in Kenya and regionally, to advocate for proactive policies that address the plight of millions of poor urban residents in the region. For example, findings from the maternal health research component of the Urbanization, Poverty and Health Dynamics (UPHD) programme, which was

nested on the NUHDSS, were instrumental in the Government of Kenya's decision to pilot the Output Based Approach Voucher scheme to fund safe deliveries, family planning services and gender-based violence recovery services in the two slum communities.

APHRC's research programmes on education and health promotion in schools, all nested on the NUHDSS platform, have also had substantial impact on the Kenyan Government's national policy on non-formal schooling and on health promotion in schools.

Beyond the two slums and Kenya, findings using the NUHDSS platform regarding high levels of unplanned pregnancies among the urban poor were instrumental in informing the Urban Reproductive Health Initiative that was jointly implemented by the APHRC and the University of North Carolina in Kenya, Nigeria, Senegal and India.

The NUHDSS is a valuable platform for the evaluation of the impact of interventions

Korogocho and Viwandani slums are increasingly the preferred choice for pilots of interventions aimed at improving the well-being of slum residents. This is partly due to the existence of data that can show pre-intervention trends, but more importantly because the situation of health and well-being in these two slums has been aptly characterized through the NUHDSS and its nested research programmes. For example, our work has led to the choice of Korogocho slum as the site for a joint initiative by the Government of Italy in collaboration with UN-HABITAT and the Ministry of Local Government, Kenya, to implement a major slum-upgrading programme.

Key NUHDSS challenges

A number of challenges affect the implementation of the NUHDSS. First, given the informal nature of the settlements, it is quite difficult to monitor the internal movements within and/or between the two slums. Second, the NUHDSS platform is repetitive and may lead to respondent fatigue. Indeed, residents who live in abject poverty and who often do not see the direct benefits of the NUHDSS in their lives may get fatigued by the exercise. However, the refusal rates are very low so far (about 2%), mainly due the efforts by the Centre to mitigate such challenges. Third, it is often difficult for the field team to work during odd hours so to be able to interview residents who mostly are not easy to find during normal working hours or in some parts of the DSA, due to the higher level of insecurity in the two slums. Finally, out-migration is high in the areas, suggesting that health and demographic indicators could be biased if appropriate measures are not taken both at the field level and during data analysis.

Measures that the Centre has taken to address these challenges include 'giving back' to the community by organizing regular, free health camps in the two slums, providing advice and supplies to community initiatives, enrolling community residents as field interviewers as they have a better knowledge of the slums and may be best trusted by respondents, and organizing community dissemination of the research findings. Much more deliberately, there are fieldworkers engaged to match internal movements within the study sites. In addition, a community relations officer helps deal with concerns from the residents and a Community Advisory Committee (CAC) was constituted in 2012 to ensure that the two slum communities are directly involved in the research activities by the Centre.

Data sharing and collaborations

NUHDSS data are shared through internal and external collaborations, in accordance with the Centre's guidelines for publications, data sharing and ethical review developed in 2008 and updated in 2013 [<http://aphrc.org/wp-content/uploads/2014/05/GUIDELINES-ON-DATA-ACCESS-AND-SHARING.pdf>]. APHRC is also part of the INDEPTH network's Sharing and Accessing Repository (iSHARE) initiative, making NUHDSS data widely shared across sites, as well as made freely available for evidence generation by researchers and policy makers in the region. The Centre has also developed a web-based platform for availing meta-data files from the NUHDSS and other research projects, and that allow online data requests [<http://aphrc.org/catalog/microdata/index.php/catalog>].

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References

1. UN-HABITAT. *The State of African Cities 2008 - A Framework for Addressing Urban Challenges in Africa*. Nairobi: UN-HABITAT, 2008.
2. African Population and Health Research Center. *Population and Health Dynamics in Nairobi's Informal Settlements: Report of the Nairobi Cross-sectional Slums Survey (NCSS) 2000*. Nairobi: African Population and Health Research Center, 2002.
3. Zulu EM, Dadoo FN-A, Ezeh AC. Urban-rural differences in the socioeconomic deprivation-sexual behavior link in Kenya. *Soc Sci Med* 2007;**64**:1019–31.
4. Taffa N, Chepngeno G. Determinants of health care seeking for childhood illnesses in Nairobi slums. *Trop Med Int Health* 2005;**10**:240–45.
5. Taffa N, Chepngeno G, Amuyunzu-Nyamongo M. Child morbidity and healthcare utilization in the slums of Nairobi, Kenya. *J Trop Pediatr* 2005;**51**:279–84.
6. Fotso J-C, Ezeh A, Madise N, Ziraba A, Ogollah R. What does access to maternal care mean among the urban poor? Factors associated with use of appropriate maternal health services in the slum settlements of Nairobi, Kenya. *Matern Child Health J* 2009;**13**:130–37.
7. Zulu E, Dadoo FN, Ezeh CA. Sexual risk-taking in the slums of Nairobi, Kenya, 1993–98. *Popul Stud* 2002;**56**:311–23.
8. Emina J, Beguy D, Zulu E *et al*. Monitoring of health and demographic outcomes in poor urban settlements: Evidence from the Nairobi Urban Health and Demographic Surveillance System. *J Urban Health*. 2011;**88**:200–18.
9. Beguy D, Bocquier P, Zulu EM. Circular migration patterns and determinants in Nairobi slum settlements. *Demogr Res* 2010;**23**: 549–86.
10. Kenya National Bureau of Statistics (KNBS), ICF Macro. Kenya Demographic and Health Survey 2008–09. Calverton, MD: KNBS and ICF Macro, 2010.
11. Faye O, Baschieri A, Falkingham J, Muindi K. Hunger and food insecurity in Nairobi's slums: an assessment using IRT models. *J Urban Health* 2011;**88**:235–55.
12. Mutua M, Kimani-Murage E, Ettarh R. Childhood vaccination in informal urban settlements in Nairobi, Kenya: Who gets vaccinated? *BMC Public Health* 2011;**11**:6.
13. Bocquier P, Beguy D, Zulu E, Muindi K, Konseiga A, Yé Y. Do migrant children face greater health hazards in slum settlements? Evidence from Nairobi, Kenya. *J Urban Health* 2011;**88**:266–81.
14. Fotso JC, Madise N, Baschieri A *et al*. Child growth in urban deprived settings: Does household poverty status matter? At which stage of child development? *Health Place* 2012;**18**:375–84.
15. Kyobutungi C, Ziraba A, Ezeh AC, Yé Y. The burden of disease profile of residents of Nairobi's slums: Results from a Demographic Surveillance System. *Popul Health Metr* 2008;**6**:1.
16. Mutisya M, Orindi B, Emina J, Zulu E, Yé Y. Is mortality among under-five children in Nairobi slums seasonal? *Trop Med Int Health* 2010;**15**:13239.
17. Yé Y, Zulu E, Mutisya M, Orindi B, Emina J, Kyobutungi C. Seasonal pattern of pneumonia mortality among under-five children in Nairobi's informal settlements. *Am J Trop Med Hyg* 2009;**81**:770–75.
18. Fotso JC, Cleland J, Mberu B, Mutua M, Elung'ata P. Birth spacing and child mortality: an analysis of prospective data from the Nairobi Urban Health and Demographic Surveillance System. *J Biosoc Sci* 2012;**45**:779–98.
19. Oti SO, Kyobutungi C. Verbal autopsy interpretation: a comparative analysis of the InterVA model versus physician review in determining causes of death in the Nairobi DSS. *Popul Health Metr* 2010;**8**:21–31.
20. Ziraba AK, Madise N, Mills S, Kyobutungi C, Ezeh A. Maternal mortality in the informal settlements of Nairobi city: what do we know? *Reprod Health* 2009;**6**:6.
21. Ziraba A, Kyobutungi C, Zulu E. Fatal injuries in the slums of Nairobi and their risk factors: Results from a matched case-control study. *J Urban Health* 2011;**88**:256–65.