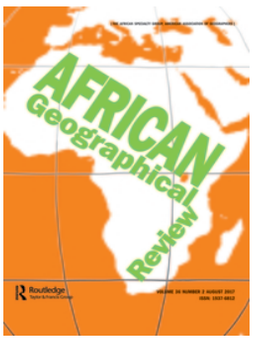

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Understanding the spatial context of sustainable urban health in Africa for the SDGs: some lessons from the corridors of deprivation in Ilorin, Nigeria

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The aim of this paper is to examine spatial clusters of urban deprivations using five domains and the influence of the observed pattern on household health status in Ilorin, Nigeria. Data were obtained through a household survey of the 20 wards of Ilorin metropolis. A systematic sampling method was used to select one out of every 10 houses in randomly selected streets in each ward while one household was selected through a simple accidental method of first contact in each building. In all, 800 household heads were sampled. A composite Index of Multiple Deprivation (IMD) was obtained by aggregating scores for each domain. Multiple correlation analysis was used to determine the relationship between the IMD and household health status. Deprivation in housing quality offered significant explanation (75.7%) for the variation in household health status ($R = .87$) ($p < .05$). Public health policies in the Post-2015 Sustainable Development Goals must consider housing characteristics within the city, classify areas according to needs, and determine areas, within the city, that require positive discrimination in health resource allocation.

Keywords: multiple deprivation; urban health; housing quality; Ilorin

Introduction and statement of the problem

Human health occupies a prime position in policy engineering to promote sustainable development which may explain the reason why health is one of the Sustainable Development Goals (SDGs) of the UN General Assembly, namely: 'Ensure healthy lives and promote well being for all at all ages' (Sustainable Development Solutions Network [SDSN], 2013). The city is therefore very critical in the ability or otherwise of nations to achieve sustainable development in the years ahead. This is more relevant in East Asia, South Asia, and Sub Saharan Africa where a significant proportion of the world's urban growth and urban poor are concentrated. The 'urban factor' will define the ability of nations to transform the social and economic fabrics because cities, in most countries, account for the bulk of production and consumption. In a nutshell, the city constitutes veritable foci of growth and development (SDSN, 2014).

Cities are, however, considered as places that are detrimental to health because some parts of cities are characterized by features that are unquestionably linked to poor health because as cities assume greater role, population density, numbers of marginalized populations, pollution, and crime frequently increase resulting in poor health and well-being for certain people in some parts of the city than outside of city. This often leads to the

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conclusion that a great contradiction exists between city size and its livability. The health consequences of this contradiction have been identified to relate to improper drainage, poor solid waste management, noise level, contaminated water, dust, and the general insanitary environment. These syndromes which generally describe housing and/or neighborhood quality are more obvious in some parts of the city than other parts. The relative lack of these environmental services in an intuitively determined measure is described as housing or neighborhood deprivation.

It must be noted that one of the criticisms of the MDGs is its heavy focus on *vertical development* intervention that targeted specific diseases or getting numbers of children in school, rather than 'horizontal intervention' with characteristic systemic views of problem themes rather than narrow targets (Converge, 2013). Thus, a spatial context is justified for the emerging SDG framework because of the required emphasis on the where of a problem rather than a problem-led approach of the MDGs. The 'urban sector' in this regard is also important first because the city is a locus of both poverty and environmental problems. Environmental services are also crucial components of economic growth and indeed more important than being mere contributors to public revenue.

In this discourse, the focus is on the degree to which the housing environment had imposed different circumstances on urban residents and how urban spaces are differentiated by these phenomena. The study focuses on the micro-level environmental interconnections with human health, which are less explored in the contemporary discourse of health, environment, and risk analysis because of the priority accorded distal influences over remote environmental problems. This is particularly important because urban administrators and planners require household-level analysis that identifies micro-level environmental sectors to which actions can be most appropriately directed to improve the health of urban residents. We argue that a SDG that is socially inclusive and environmentally sustainable must include a micro-level environmental priority such as those that border on housing, water, and sanitation as demonstrated in the case study of Ilorin, Nigeria.

The paper engages the understanding of the relationship between housing qualities, expressed in terms of deprivation domains, and health status of urban households. The understanding of this aspect of urban services provides an engaging perspective on environmental problems and attendant health consequences at both neighborhood and household levels.

Urban health in the context of sustainable development in Africa: issues, perspectives and challenges

Human health and sustainable development are connected in more than one way. First, because actions at local levels are particularly important for achieving both healthy living and sustainable development and second, because health, as a human right, is also crucial to achieving the four priority objectives - economic development, social inclusion, environmental sustainability, and good governance – on which sustainable development paradigm is premised. This explains why the United Nations Programme of Action on Sustainable Development, otherwise referred to as Agenda 21, also 'comprises a framework for actions for sustainable development that focuses on economic, environmental, socio-demographic and health factors' (WHO, 1997a). In the same vein, the European Strategy for health for all provides a clear guidance on actions that may be taken for health reasons but which share the fundamental principles of Agenda 21 (WHO, 1991).

It is, however, a paradox that there is a simultaneous deterioration of public health and the state of the environment despite the growth in the global initiatives, memoranda, and blueprints designed for health promotion strategies. This, according to Kjærgard, Land, and Pedersen (2013), could be linked 'to the inadequate integration of health promotion and sustainability dimensions at local, regional and global levels'. In the African context, the health–poverty–environment nexus is at the heart of this paradox because of the obvious but complex link between 'poor urban living condition, poor quality of life, adverse effects on health and adverse effects on the environment' (WHO, 1997b).

Health and sustainability is therefore produced by the intersection of the trio of a viable environment, an equitable economy and convivial social values within a society. Environmental or ecological sustainability expresses the in-field measurement of air pollution (MacKerron & Mourato, 2008) or industrial metabolism in terms of material flows and transformation caused by different industries or other environmental problems (Anderberg, Prieler, Olendrzynski, & de Bruyn, 2000; Koglin, 2009). Generally speaking, ecological component of sustainability builds on the scientific evidence of environmental problems and analysis of these problems (Ekins, Dresner, & Dahlström, 2008; Grimm et al., 2008). Xu et al. (2008) also explained ecological sustainability through the urban ecological system that connects social–economic and natural/ecological aspects into a complex system which implies the utopian vision of the ecocity which connects all aspects of urban sustainable development.

According to Blewitt (2008), economic dimension of sustainability offers a technocratic approach to environmental problems suggesting that growth in productivity and development must lead to gains for the poorer quartile of the society through a trickle down of the gains of economic growth in the form of job creation and more taxes for welfare.

A number of urban environmental factors have implications both on human health and sustainable development. At the micro-level, Galea, Freudenberg, and Vlahov (2005) identified 'what people eat, the air they breathe, and the water they drink, where (or if) they work, the housing that shelters them, their sex partners and family arrangements, where they go for health care, the dangers they encounter on the street, and who is available for emotional and financial support' as major social determinants of urban health status because these factors may on their own constitute risks or are determinants of exposure to other health risks within the city. A clear understanding of the complex interaction of these characteristics of the city and the implications on health of residents is desirable for fashioning out interventions strategies in the post-2015 Sustainable Development agenda.

In this paper, the example of urban housing is used, first, to emphasize the centrality of housing as a unifying factor in urban living that could be broadly defined to encompass most of the factors identified by Galea and others as cited above; and secondly, to isolate housing conditions in Africa as a critical reflection of the living conditions of urban residents, as well as a major determinant of their health status. Moreover, as noted by Kjellstrom (2007), the core concepts of social and physical environments that define the urban context are also shaped by multiple factors and multiple players at multiple levels (see also Vhalov et al., 2007). In a nutshell, urban health is better understood through a disaggregation of the urban environmental context into the least possible micro-level of the household because this is the unit that could be targeted for 'complete ethnographic enumeration' of the city population since all individuals in the city belong, or are expected to belong, to a household.

Deprivation in working and/or living conditions, as expressed in terms of poor access to safe drinking water, poor sanitation, poor residential quality, etc., constitute risk factors to health of urban residents and the level to which residential neighborhoods are deprived in terms of these resources and services also vary for different areas of the city. This may also explain the intra-city variation in health conditions, disease prevalence, and health status within the city.

The comparisons of the disparities in health care, use, and health status have depended upon the bounding of populations by geography as much as by other factors including race, ethnicity, income, and employment. In other words, the factors that drive disparities often define them geographically. Thus, we tend to speak of 'low income neighbourhoods' 'minority communities' as defining characteristics of places (Ricketts, 2003).

Deprivation is a generally accepted method of identifying population with poorer health (Schuurman, Bell, & Dunn, 2007) because indices of deprivation are useful in identifying localities where a high proportion of households are exposed to adverse social, economic, and environmental conditions that may also affect their health (Bartley & Blane, 1994).

In this regard, few studies exist in African health or urban literature that explores social determinants of health using socioeconomic data to quantify deprivation and demonstrate its relationship with population health. Indeed, when data source and type is taken into account, studies that use cross-sectional household survey to explore household-level deprivation and human health are rare which makes the case study reported in this paper both an experiment in the use of cross-sectional data for deprivation studies as well as a contribution to fill the gap in the Africa urban and health literature in the area of social and environmental determinants of health in cities.

Urban health in Africa and corridors of deprivation: the Ilorin example study setting

Ilorin, the capital city of Kwara State, Nigeria is the setting for this study. The city is located on latitude 8°30′ N and longitude 4°35′ E marking a division between the southern forest zone and the Northern grassland of Nigeria (Figure 1(a)).

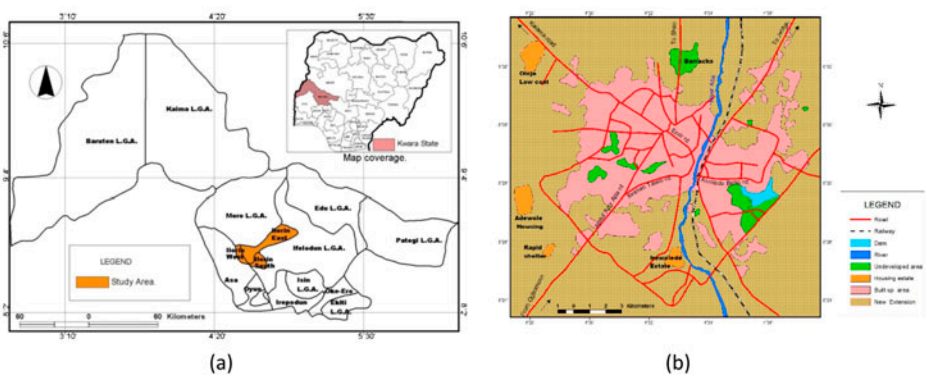

Figure 1. (a) Ilorin at the regional setting, (b) Ilorin built up area.

The city is a typical traditional African city whose urban history predates colonialism in Nigeria. Ilorin falls into the category of third world cities described as reputed for their dualistic internal structure (Mabogunje, 1968). Within the city, it is possible to delimit, even if roughly, residential groupings determined by both the housing density and their crowding index. Generally, Ilorin's growth and structure can be situated within the interplay of the role of the three classical ecological theories of urban morphology (Figure 1(b)). The physical development of Ilorin translates into significant change in the population of the city from 36,300 inhabitants in 1911 to a projected population of about 814,192 by the year 2015 at the rate of 2.84% annually (GeoNames Geographical Database accessed from http://www.geonames.org/maps/google_8.497_4.542.html on 11 August 2015). The facts of urbanization, development of the modern commercial/industrial economy and the multiplier effects of these factors on natural increase had combined to produce the changes in population described above.

Materials and methods

The data for this study were drawn from a city-wide survey of households in Ilorin metropolis conducted to examine the influence of housing quality deprivation on health of residents in Ilorin city (Raheem, 2012).

A multistage sampling technique was used to select the households for the survey. The sampling frame for the survey is the total number of households in Ilorin metropolis as given by the 2006 population census. There are 20 traditional wards in Ilorin metropolis which generally encompass the built up areas of the city. The wards are Alanamu, Ajikobi, Filani, Gambari, Mogaji Are, and Mogaji N'Geri, which are classified as inner-city wards. On the other hand, Okaka, Badari, Babaoko, Oke-Ogun, Ibagun, and Oju-Ekun wards were classified as wards in the frontier native areas of the city; the Estates wards are Oloje, Adewole, Zango, and Ubandawaki, while the remaining wards, namely SaboN'Geri (1 & 2), Ogidi and Zarumi were referred to as the Suburbia wards. It must be noted that this classification is for the convenience of analysis and based purely on the historical and urban development structures observed for the city of Ilorin. Hence, 800 households were sampled, representing approximately 10% of all households from each of the 20 wards of the city. Most of the houses, particularly in the indigenous areas, were 'family houses' inhabited by several households and heads of households were the target respondents. Within each ward, a systematic random sampling method was adopted informed by the relative homogeneity of household characteristics and the residential structure of the neighborhoods. This was followed by constructing deprivation indicators as well as aggregating the indicators into composite measures (Equation (1)).

The study relied on data from different government agencies and institutions to derive the deprivation benchmarks for the variables used in the study. These include the Nigeria Demographic and Health Survey and Nigeria DHS EdData Survey, the Coverage Estimates for Improved Drinking Water, and Sanitation for Nigeria by the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, as well as the Nigerian Statistical fact Sheets on Economic and Social Development.

Deprivation indices

The study adopts non-monetary indicators of poverty and deprivation. This is because in most empirical studies where the standard of living is measured by the household

income adjusted to size by means of equivalent scales, important indications of household deprivation are ignored or taken for granted (see Martinez & Ruiz-Hueta, 2000). Thus generating data for this study entails several interrelated steps. These include choosing a set of indicators of deprivation, evaluating the household situation for each of the identified indices, and defining a weighting structure to aggregate the indicators.

The choice of deprivation indicators is often informed by the research goal. Within the literature, there has been a range of empirically based indicators designed to account for urban deprivation (Baum, Stimson, O'Connor, Mullins, & Davis, 1999; Baum, O'Connor, & Stimson, 2005; Chakravorty, 1996; Department of the Environment Transport & the Regions [DETR], 2000; Midgley, Hodge, & Monk, 2003; Rahman, Palmer, Kenway, & Howarth, 2000). While all of these approaches cover various aspects of socioeconomic deprivation, they vary in terms of the method of indicator construction, the types of individual measures used and the spatial scale at which deprivation is measured. Common indicators of deprivation include income level (both of households and individuals), levels of unemployment, and labor force participation, all of which are considered to be direct measures of relative deprivation. In addition to these variables, some research (depending on data availability) use indicators relating to housing condition or quality, while others make use of social problem indicators such as crime or health data (Bentham, 1985; Williams & Windebank, 1995).

From a design view point, some measures take standardized data and produce unweighted indices (Carstairs & Morris, 1989), while others (Baum et al., 1999; 2005; Bentham, 1985) make use of multivariate methodology to derive typologies of localities based on a range of socioeconomic variables. Finally, considering spatial units, the choice made depends on the level of aggregation at which data are available and include suburbs, neighborhoods, local boroughs, and local government authorities and enumeration districts (Baum et al., 1999; Bradford, Robson, & Tye, 1995; Chakravorty, 1996; Sloggett & Joshi, 1998). In other words, it is not easy to determine which or how many indicators should be taken into account in measuring deprivation. The selection comes from 'a trade off, between the possible redundancy caused by overlapping information and the risk of obviating some important variables' (Perez-Mayo, 2005). Thus this study, having recourse to the indicators used in earlier studies, chose indicators from those often used in the literature that were considered relevant to developing countries and the goal of the study.

The study proceeds with an assumption that multiple deprivations are made up of separate dimensions or domains and that each of these domains were made up of a number of indicators. Given this assumption, the following domains of deprivation were selected for the study:

(1) Education
(2) Housing Quality
(3) Residential Services
(4) Employment, and
(5) Geographic Access.

Thus, deprivation indices were defined, using a structured questionnaire, to express the inability of households to access living conditions that were classified as adequate for a healthy living.

Based on the foregoing deprivation, each of the above domains were defined by the variables in Table 1. Wards were classified as deprived if the proportion of its sampled

Table 1. Domains of housing deprivations.

S/No	Domain	Indicators	Benchmark (%)	Source
1	Education	i. Illiteracy rate	31	NPC, 2004
		ii. Number of school dropouts	47	
		iii. Out of school children	17	NBS, 2005
2	Housing Quality and congestion	iv. Proportion of households in houses without plastered floor	11	
		v. Proportion of households in Nigerian cities where walls of houses were made of mud or unbaked blocks	7	NBS, 2005
		vi. Proportion of households occupying multi-family houses or rooms in large dwellings	68	
		vii. Proportion of households using less than three rooms	46	
		viii. Proportion of households where three or more persons occupy a sleeping room	58	
3	Residential Quality	ix. Proportion of households fetching domestic water from 'unsafe' sources	50	NBS, 2005
		x. Proportion of households without WC in Nigerian cities	44	WHO/UNICEF, 2008
		xi. Proportion of households sharing toilet facilities	34	NBS, 2005
		xii. Proportion of households not connected to central electricity	15	NPC, 2004
4	Employment	xiii. Proportion of households where at least one adult is not in paid job	13	NPC, 2004
		xiv. Proportion of households with at least one adult without secondary education	37	
		xv. Proportion of households where at least one adult is ill in the last six months	26	
5	Geographical Access to basic services	xvi. Proportion of households located farther than 15 min trekking distance to the nearest public health facility	24	WHO/UNICEF, 2008
		xvii. Proportion of households located farther than 15 min walking distance to the nearest primary school	18	NPC, 2004
		xviii. Proportion of households located farther than 500 m walking distance to the nearest stand pipe source	31	NBS, 2005

households lacking in the respective indicators was greater than the benchmark (national average) for the indicator in question**.**

Health indicators

One of the most challenging aspects of ecological studies of health at the household level is the methodology of selecting health indicators and/or outcomes. This is because unlike the health effects of physical, chemical, and biological hazards in the home, the health effects of socioeconomic dimensions of housing and neighborhood are less immediate and less acute. They have long latency periods and may not lead to illness to be diagnosed for many years (Dunn, 2002). This presupposes that measures of health other

than clinically diagnosed illness may be more appropriate. Therefore, self-reported general health measures were used, which is 'very robust in predicting future incidence of a wide variety of conditions, including mortality and correlates highly with symptom reporting scales, as well as future mortality and morbidity' (Dunn, 2002); aside from this, the indicators are also measures of health conditions from the perspectives of non-fatal outcomes (Kunst, Roskam, & National Representatives, 2003). Thus, the health indicators used in this study are

- household self-rated health status,
- households reporting hospital admission in the six months preceding the survey
- household reporting disability days (whose member(s) lost at least one day in a month to ill health)
- occurrence of childhood diarrhoea in households, and
- health care options first adopted when illness occur.

These variables were selected to capture health status perception, health in households, health of children, and health-seeking behavior during illnesses.

Identifying corridors of deprivation in Ilorin Metropolis

The spatial pattern and concentration of deprivation is examined using a general index of multiple deprivations for each ward. To do this, percentage scores of indicators of deprivation in Table 1 were averaged for each domain. Since these are percentages of the population affected by the type of deprivation, the scores can be combined. Thus, relevant indices of deprivation under each of the five domains were aggregated to obtain a composite measure of deprivation for each domain and across the twenty wards of the study area.

An overall index of multiple deprivation (IMD) is computed for each ward using the 1997 UNDP development index as modified by Jamal, Khan, Toor, and Amir (2003). The IMD is calculated for each ward by the expression in Equation (1) as follows:

$$\mathrm{IMD} = 1/(100n)\{E^y + \mathrm{HQ}^y + \mathrm{HS}^y + L^y + G^y\} \quad (1)$$

Adapted with modification from Jamal et al. (2003).

where IMD = Index of Multiple Deprivation for Ward i, E = Index of Education Deprivation, HQ = Index of Deprivation in Housing Quality, HS = Index of Deprivation in Residential Services, L = Index of Deprivation in Employment, G = Index of Deprivation in Geographical Access, $y = 3$, and n = number of domains of deprivation under review.

'y' is a measure of the weight of each domain based on its value. According to Jamal et al. (2003), 'y' rises; the greater the value of deprivation in the domain. The value of 'y' has an important impact on the value of IMD. If $y = 1$, the index is the average of its five sectors and the outcome varies as the roots of deprivation domains vary. Thus following the UNDP (1997), the value of y is set at 3 to give additional but not overwhelming weight to the area of greater deprivation.

$n = 5$ (number of domains of deprivation under review)

With this technique, it is possible to identify the most deprived or the least deprived ward by simply ranking household index of multiple deprivations in order of magnitude. In other words, IMD values represent the magnitude of deprivation suffered by households

in each ward when all variables are taken together. Thus, the IMD score for each ward is suitable for comparing spatial units on the scale of quality of life.

Having obtained the IMD above, the study proceeds to test its main hypothesis that the household health status in the city is a direct function of the magnitude of deprivation in housing and neighborhood conditions in the city. The paper also examined the relative impact of each of the deprivation domains to the observed health conditions of sampled households.

Each column (except the last) in Table 2 represents average of the scores in all indicators used in each domain of deprivation selected for this study. Equation (1) above was employed to compute the composite score for all the domains put together. This composite indicator is otherwise referred to as the IMD. The last column of Table 2 is a comparison of the multiple deprivations in each ward of Ilorin metropolis with the most deprived ward in the city. In other words, using the highest IMD (1550.79) as the denominator, percentage deprivation for each ward was computed as

$$\text{IMD}\ (\%) = (\text{IMD}_i/\text{IMD}_h) \times 100 \tag{2}$$

where IMD_i = Index of Multiple Deprivation for ward i, IMD_h = Highest Index of Multiple Deprivation.

Table 2. Pattern of deprivation in Ilorin Metropolis.

Ward	Index of deprivation in					Index of multiple deprivation (IMD)	IMD as % of the highest IMD
	Education	Housing Quality	Res. Quality	Employment	Geog. Access		
Adewole	12	7.6	9.3	13	12.7	14.43	.9
Ajikobi	14	39.8	38.3	14	60	681.43	43.9
Alanamu	8	39.0	47.8	52	31	678.89	43.8
Mogaji Are	16	41.2	46.8	19	31	426.37	27.5
Babaoko	25	20.2	20.3	31	15.3	131.21	8.5
Badari	33	36.6	26.5	33	57	649.41	41.9
Balogun Filani	11	29.6	28.5	19	55	447.30	28.9
Gambari	43	35.4	42.3	35	53	782.62	50.5
Ibagun	49	37.2	39.8	42	58	1002.75	64.7
Mogaji N'geri	19	33.8	25.8	13	23	154.02	9.9
Okaka	30	32.6	35.3	19	11	227.65	14.7
Ogidi	44	28.4	35.8	50	66	1132.94	73.1
Oju-Ekun	36	32.2	42.0	23	42	480.77	31.0
Oke-Ogun	43	51.4	51.5	53	65	1550.79	100.0
Oloje	41	36.6	35.3	49	42	707.35	45.6
Sabon Geri 1	12	7.2	8.0	13	8	10.64	.7
Sabon Geri 2	14	11.4	8.8	09	8.7	12.59	.8
Ubandawaki	30	37.8	28.5	28	18.6	265.09	17.1
Zango	13	17.4	2.5	28	12	79.52	5.1
Zarumi	34	46.7	37.0	11	42	534.45	34.5

Source: Raheem (2012)

This is to enable us to obtain a statistical comparison of multiple deprivation across the wards of Ilorin metropolis. Thus, it is possible to quantify the percentage of multiple deprivation suffered by each ward in relation to other wards in the city.

Examining the impact of deprivation on health

By hypothesizing that the levels of health of households in Ilorin metropolis are functions of the deprivation in the different domains (Table 2), there is the need to incorporate the complex environmental and socioeconomic conditions of urban neighborhoods and housing with human health conditions in a multivariate analysis.

Thus, the multivariate statistical technique of canonical correlation analysis was adopted because both deprivation and health are multivariate phenomena which can be (and were) measured using a number of variables as shown in the two tables and identify the associations among the variables (Hopkins, 1969; Henson, 2000; Laeisig & Duckett, 1979). A functional relationship between health (H) and deprivation is of the form:

$$H = f(D) \tag{3}$$

where D (Deprivation) is the predictor variable proxied by the five variables shown in Table 3 and H (Health) is the criterion variable measured using the five domains shown in Table 3.

Five equations were derived i.e. for H_1–H_5 and D_1–D_5.

Table 3. Household health characteristics in Ilorin Metropolis.

Ward	Household health status	Admission ratio in households	No of disability days in households	Occurrence of childhood diarrhoea	Adoption of substandard health care options
Adewole	3	13	33	25	3
Ajikobi	10	5	10	13	48
Alanamu	33	5	25	33	45
Are	23	5	18	25	65
Babaoko	3	45	23	68	45
Badari	3	33	45	55	68
Balogun Filani	10	15	38	30	53
Balogun Gambari	20	35	53	88	55
Ibagun	8	48	25	13	40
Mogaji Geri	30	55	68	30	30
Okaka	13	45	25	95	75
Ogidi	28	50	53	53	60
Oju-Ekun	20	13	58	40	65
Oke-Ogun	45	43	88	50	45
Oloje	13	23	95	3	40
Sabon Geri	8	10	30	8	8
Sabon Geri 2	0	8	15	15	3
Ubandawaki	0	45	65	75	40
Zango	0	10	28	80	15
Zarumi	43	0	23	90	68

Source: Raheem (2012)

The essence of canonical analysis is the formation of pairs of linear combinations of the predictor and criterion variables in such a way as to maximize the correlation between each pair. Thus, the objective of using a canonical correlation analysis is to determine sets of weights (i.e. vectors of coefficients) which, when applied to our two sets of variables (Health and Deprivation) will produce pairs of maximally correlated linear combinations of the sets.

This is expressed as the derivation of a series of vectors $\boldsymbol{u}$ and $\boldsymbol{v}$, such that if

$$P_i = U_{i,1}X_1 + U_{1,2}X_2 + \ldots U_{i,m}X_m \tag{4}$$

$$C_i = V_{i,1}y_1 + V_{1,2}y_2 + \ldots V_{i,n}V_n \tag{5}$$

then

P_i will be maximally correlated with C_i for each i in the series.

where X_1-X_n = predictor variables (Deprivation), y = Criterion variables (Health), m = the number of predictor variables, n = the number of criterion variables, i = the number of the canonical correlations will equal the smaller of m or n.

In the present study, $m = n = 5$.

Table 4 shows the results of the canonical correlation analysis between the predictor (Deprivation) and criterion variables (Health) for Ilorin Metropolis.

Analysis and major findings: corridors of deprivation in Ilorin Metropolis

According to Table 2, Oke-Ogun ward is shown to be the most deprived ward in the city with a theoretical 100% multiple deprivations. This is followed by Ogidi and Ibagun wards with 73.1 and 64.7% multiple deprivations, respectively. It is important to note that Oke-Ogun and Ibagun wards are located in the Frontier Native Zone while Ogidi is a suburbia ward. The former include areas immediately after the inner-city that has suffered from multiple disadvantages arising from lack of access, dilapidated housing structure as well as high level of poverty among the inhabitants (Figure 2).

On the other hand, Sabon Geri 1 and 2 wards are shown to be the least deprived in the city with a multiple deprivation index of .7 and .8%, respectively. This is expected since the wards are almost entirely composed of the Government Reserved Area (GRA) where government residential quarters and the residence of the elites are located. The wards have therefore benefited from the provision of decent housing and residential conditions as well as improved access to basic facilities.

This is followed by Adewole (.9%) and Zango with 5.1%. These wards are the wards where government estates are located, including Kulende, Adewole, and Royal Valley housing estates, which were provided with basic facilities like access roads, good layout of water, and electricity infrastructure as well as well-planned neighborhood drainage systems.

Household health characteristics in Ilorin Metropolis

The paper explores household health characteristics by identifying the intra urban variation in the five indicators used to measure household health status, and response to ill health and disease occurrence. The study uses five rankings of self assessed general health status. The survey asked respondents to rate their own health and those of other household members as being ‘Excellent, Very Good, Good, Fair or Poor’. Increase in these measures is taken to correspond to better health. In this study, the interest is in the

Table 4. Symmetric correlation matrix between deprivation and human health in Ilorin Metropolis.

	Hhhstatu	Admratio	Disday	Chiddrr	Hcareopt	Edudep	hQuality	Resqty	Empdep	Geoadep
Hhhstatu	1.0000									
Admratio	.0253	1.0000								
Disday	.2975	.4675	1.0000							
Chiddrr	.1425	.2747	.0061	1.0000						
Hcareopt	.4267	.1885	.0764	.4390	1.0000					
Edudep	.3225	.2670	.5645	.0188	.5324	1.0000				
Hquality	.3863	.0518	.1308	.0030	.2516	.1468	1.0000			
Resqty	.6422	.02396	.2293	.1559	.1227	.3920	.7448	1.0000		
Empdep	.2494	.3270	.4697	.0758	.0915	.4831	.1903	.4345	1.0000	
Geoadep	.1026	.1291	.1850	.0933	.7272	.4106	.1974	.1789	.4166	1.0000
Canonical variates: .8728 .6755 .2513 .2202 .0807										

Notes: Hhhstatu: Household health status, Admratio: Admission ratio, Disday: Disability days, Chiddrr: Childhood diarrhoea, Hcareopt: Health care option, Edudep: Educational deprivation, Hquality: Housing quality, Resqty: Residential quality, Empdep: Employment deprivation, Geoadep: Deprivation in geographic access.
Source: Raheem (2012)

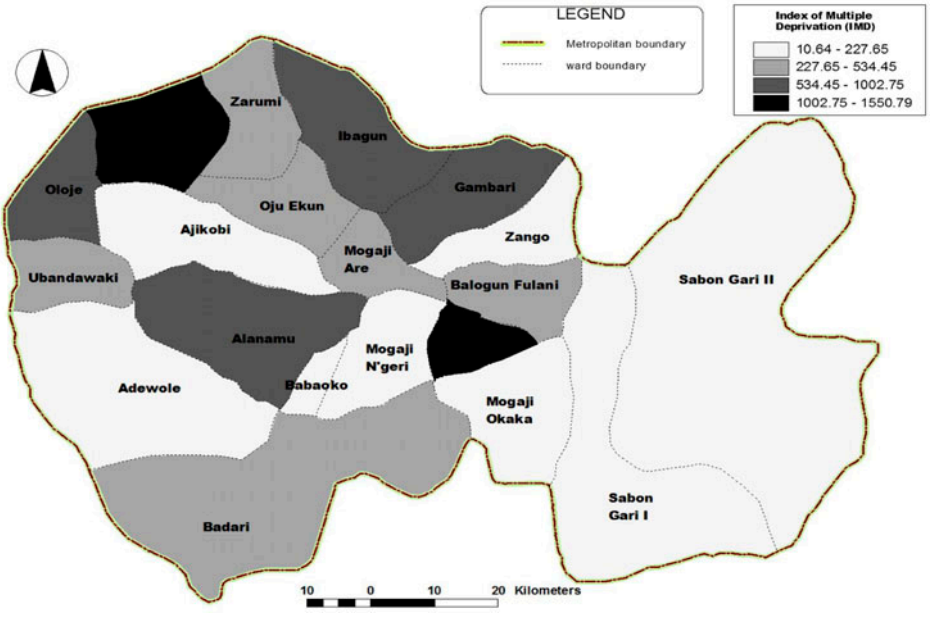

Figure 2. Corridors of deprivation in Ilorin Metropolis.

identification of the distribution of negative or low health status. Thus, the last two categories in the five-category ranking, i.e. households with 'fair' or 'poor' health status, were used to obtain the proportion of households with 'unsatisfactory' health status.

The first five wards in the study area with the poorest health conditions are inner-city wards while the inhabitants of the Suburbia and Estates wards are generally healthier. The three wards, namely Adewole, Ubandawaki and Zango, with the highest rating of household health are in the Estate zone while Sabon Geri 2 is in the suburbia.

Admission rate in hospitals is an important indicator of the disability days measuring the average number of days lost in the last one month due to illness. The survey also shows that the first seven wards with the highest admission ratio were Inner city and Frontier native wards. These wards are noted for high poverty and low income, which combine to make illness a huge challenge for households. On the other hand, the Estates and Suburbia wards have low rates of admission per household.

Disability Days in Households is a measure adapted to mirror the WHO's Disability Adjusted Life Years (DALY), which measures the proportion of households whose members could not contribute to household economy due to ill health. It is also gives 'an indication of the degree of health problems within a particular area' (Bardsley & Morgan, 1996). It is one of the few indicators that is able to capture illness cases that might not have been reported in the hospital or for which patients were not admitted overnight. Up to 95% of households at Oloje lost at least one day of economic activity to ill health. Three other wards, Oke-Ogun (88%), Mogaji N'Geri (68%) and Ubandawaki (65%) are among the wards with the highest proportion of households with disability days lost in three weeks.

Infant and childhood health are considered to be valuable comparative indicators of the health status of a community (Wilkinson, 1994). Diarrhoea is chosen for this study

because it constitutes one of the top five preventable killers of children less than five years in developing countries (Gerald et al., 2006). There were no households reporting diarrhoea among their children in the Sabon Geri wards while in Adewole 25% of households reported episodes of the disease in their children. It is important to note the excessive prevalence of diarrhoea in Zango (90%). This is the only ward in the suburbia/GRA zone with such high diarrhoeal prevalence. The ward encompasses high density residential areas like Maraba, Kulende, and Zango. These areas of the city house middle- and low-income households with poor and substandard housing and sanitation conditions. The spatial pattern of childhood diarrhoea observed in this survey is consistent with the pattern of human feces exposure, poor sanitation, poor access to clean water, and inadequate personal hygiene in the city. These factors have been estimated to account for up to 90% of childhood diarrhoea (WHO, 1997b), which is also complicated by poor education of nursing mothers (Tobin, Isah, & Asogun, 2014).

The health care option adopted by people is a reflection of the predisposing factors affecting the utilization of health care (Arcury, Wilbert, Sherman, Spencer, & Perin, 2005). It is important to underscore, from the comparison of the occurrence of childhood diarrhoea with the health care options, that the distribution of these two variables is similar. Okaka, with the highest proportion of households reporting childhood diarrhoea (95%), also has the highest proportion of households adopting the substandard health care option as first choice when illness occurs. While not implying a causal relationship between the two variables, it is important to indicate the implications of this coincidence for diarrhoeal treatment as well as for infant and under-five mortality in cities. This coincidence implies that in areas where the highest occurrence of childhood diseases like diarrhoea is reported, the first health care option is not orthodox medicine. As shown in the study, various other health care providers are consulted to provide advice on the sick child, which may increase the fatality from diseases like diarrhoea especially, among children aged five and below.

Impact of deprivation on health of urban residents

As shown in the Table 4, the variance in health status (the first criterion variable) accounted for by the joint contributions of the five deprivation domains is 75.7% ($R^c = .87$). This can be regarded as the best overall correlation obtainable using linear combinations of the given variables. It means that the variation in household health that is accounted for by the five domains of deprivation is about 76%. Although canonical correlation cannot be negative (Gonzalez, Dejean, Martin, & Baccini, 2008), if a signed correlation coefficient is required, the sign must be indicated in accordance with the logic of the relationship. Hence, in the case of household health status and the domains of deprivation, the positive relationship is accepted as valid because health status is measured as the proportion of households with negative self rated health in the survey. It is thus expected that the higher the deprivation in the various domains used in the analysis, the poorer the health of household members (hence $r > 0$). This also means that health status as perceived by households is directly related to the levels of deprivation suffered by households

At the individual variable levels, residential quality accounted for about 41% of the variation in household health ($R^c = .64$). This is followed by the impact of education deprivation on household health with ($r = .32$). Geographical Access domain of deprivation shows the least association with health of households ($r = .10$).

Hospital admission ratio is measured as the proportion of households whose member(s) stayed at a hospital overnight in the six months preceding the survey. The association of this with the different domains of deprivation shows that all domains of deprivation except housing quality domain fulfilled the *a prori* expectations. The explanation of this criterion variable (admission ratio) by the joint contribution of the predictor variables (deprivation) is $R^c = .68$. This means that 46% of admission cases could be explained by the occurrence of deprivation in the five domains. At the individual variable level, deprivation in the employment and education domains had higher correlation, $R^c_{(empldep)} = .33$, $R^c_{(edudep)} = .27$. These two variables are related, because levels of education (in a way) affect adult employment status. This relationship may therefore be explained as reflecting the tendency in households with unemployed heads to experience higher episodes of serious illness that may require hospital admission.

Disability days is an important measure of Health-Related Quality of Life (HRQoL) developed by the Centre for Disease Control. Specifically, disability days are measured by the number of 'recent days' lost because of poor physical or mental health, with the term 'recent' defined as the past 30 days (Centers for Disease Control & Prevention [CDCP], 2003). The objective here is to test whether deprivation predicts disability days and to identify the domain of deprivation that offers the highest explanation for the disability days. The result shows that education and employment deprivation offer the highest levels of explanation for disability days in households in Ilorin metropolis with 32.5 and 22% ($R^c = .57$ and .47), respectively. It is important to note that the explanation of disability days that is offered jointly is only 6%, which is the variation in disability days explained by the joint effects of the predictor variables. It must be noted that in a canonical correlation analysis, the first pair of linear combinations is formed so that the correlation between the two sets of variables is maximized and the second pair is also as large as possible but subject to the constraint that the second pair is uncorrelated with the first, etc. As a result, successive canonical roots get smaller. This is why it is safer to obtain a joint test for the measure of significance for the dependency of the canonical *variates.*

As shown in the table, most of the domains of deprivation correlate poorly with childhood diarrhoea among sampled households. This is curious because it is an established fact that severe deprivation is likely to have adverse consequences for human health, yet the domains of deprivation used in this study did not show a significant relationship with the occurrence of childhood diarrhoea ($Rc = .08$). In other words, the result of the analysis in this study suggests that deprivation has little explanation to offer for the occurrence of childhood diarrhoea. The probable reason for this result is that parents might have developed coping mechanisms overtime, which serve to reduce the impact of deprivation on children (Raheem, 2006, 2013).

Two domains of deprivation appear to be dominant in the explanation of the use of substandard health care options by household: deprivation in geographical access and education. The result shows that geographic access to basic services explains 53.3% of variation in the number of people who used substandard health care, while deprivation in the education domain explains 28% of the said variation ($R^c = .73$ and $R^c_{edudep} = .53$). Although deprivation in geographic access is measured using a number of surrogates, they all express the importance of the 'distance factor' in the magnitude and/or severity of deprivation to which households are exposed.

Summary of findings

The study found that wards in the inner city and Frontier Native wards were shown to be the most deprived areas and a significant variation in the Index of Multiple deprivation among the four residential zones to which Ilorin metropolis was divided on the basis of historical development. The results suggest that the oldest parts of the city suffer multiple deprivation more than the relatively new neighborhoods; however, multiple deprivation occurs in spatial clusters in the city with pockets of deprivation existing in close proximity with areas of low deprivation. Generally speaking, the study is able to identify 'social areas' based on a combination of population variables and areal characteristics to obtain distinguished geographical units with distinctive characteristics within the city, which gives credence to the idea of social area analysis used in this study. The study explored the relationship between household health and deprivation in different domains using the method of canonical correlation because of the *multidimensional* nature of the two variables – health and deprivation. The method enables us to demonstrate, simultaneously, the relationship between a number of dependent and independent variables. The result shows that the variation in health of households accounted for by the joint contributions of the five domains was 75.7%, indicating that household health status is directly related to the levels of deprivation and residential quality as the greatest influence on household health in the study area. In other words, indicators like the source and quality of water available to households, type and ownership of toilets, availability of bathroom and kitchens were shown to be important for the health status of households. This finding corroborates the 'triangle of human ecology of disease,' where the 'built environment' vertex encompasses the residential quality or the habitat conditions and that changes in these conditions may result in profound alterations of the disease conditions in household (Meade, Florin, & Gesler, 1988).

Towards a sustainable urban health in Africa: some concluding remarks

Urban health is better understood through a wide range of factors interacting at various scales and levels; the most important of these factors being economic, environmental, geographic, historic, political, and social characteristics of the city. These may also vary widely for different areas of cities and the influence on health of urban residents can be synergistic or antagonistic to multiply or diminish observed effects.

As shown in the Ilorin example, a deprived housing facility falls short of environmental performance principles - a key concern for sustainable designs of human dwellings. The spatial taxonomy adopted to classify the city into historical zones revealed that urban health in Africa is intricately linked to the colonial spatial planning system designed to support spatial segregation and population control. These planning systems fail, somewhat woefully, to reflect the need and priorities of post colonial urban residents because the model is both unaffordable and inadequate in addressing the environmental requirements of today's complex and interconnected urban system. For instance, urban planning in most pre-colonial cities tend to abandon the indigenous areas of the city to dwellers, who for reasons of poverty or need for social support, continue to construct structures that fall short of healthy city principles. It must be noted that many homes in the inner parts of pre-colonial African cities are without toilets, such as those found in Ilorin, with 43% for the city, and 83% for the inner city areas, or without separate kitchen or septic facilities (Raheem, 2012). This clear deficit in availability of housing facilities like toilets, kitchens, and *bathplaces* has serious implications for open

defecation and surface flow of grey water in neighborhoods. Thus, municipal governments must make deliberate efforts to overhaul housing facilities in their areas. This could take the form of a desperate urban renewal strategy through a deliberate policy that mandate all house owners to provide these facilities in their houses within a stipulated time period. As a short term measure, local governments may embark on a massive provision of toilet facilities in public locations to reduce open defecation and human-fecal contact.

For Africa and its cities, SDGs must elaborate on slum dwelling to include not only informal settlements, but also obvious dilapidation in structure and infrastructure characteristic of the pre-colonial inner areas, such that indicators of the goals capture micro-level urban governance strategies that prioritize amenity, safety, and convenience in cities. This speaks directly to sustainable development indicators that are sensitive to environmental performance in dwellings and neighborhoods. The indicators must capture energy efficiency, water, transport, sanitation, indoor air quality, noise, accessibility, population crowding, and waste handling. The complex interplay of these housing and neighborhood qualities is expected to produce improved and sustainable human health in cities.

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No potential conflict of interest was reported by the author.

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