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AN AUDIT OF URBAN NEIGHBOURHOODS IN METROPOLITAN LAGOS, NIGERIA

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ABSTRACT

Goal 11 of the Sustainable Development Goals concerns the safety and sustainability of urban centers. This project audited neighbourhoods in metropolitan Lagos as an example of how to characterize facets of the built environment that may affect urban health and sustainability in emerging African cities. The audit was administered in 72 purposefully selected segments. Six continuous built environment features were observed namely residential, commercial and public service destinations, street characteristics and recreational facilities. Wide variation in features suggested a need for proactive neighbourhood planning.

Physical disorder, power supply, waste management, governance and road infrastructure were the most urgent challenges. To ensure health and sustainability, interventions need to leverage informal governance arrangements and build community stewardship. Given high levels of utilitarian walking, provisions for safe walking and biking are needed. An exploratory factor analysis identified residences and community services, commercial services and recreational facilities as the neighbourhood features in this context.

Keywords: built environment audits, healthy cities, resilient cities, sustainable cities, urban neighbourhoods, Lagos metropolis urban health, urban governance, healthy urban planning

BACKGROUND

Ensuring that African cities are resilient is a critical task that must be undertaken to achieve and sustain the Sustainable Development Goals (Amusat, 2016). However it is more often the case that urban outcomes in African cities are unsustainable given that they do not sufficiently address ecological concerns and inequalities (Obeng-Odoom, 2014). Additionally, urban poor contexts are underrepresented globally in urban public health governance and data collection (Clemans, 2015) thus limiting an understanding of how to improve their sustainability. A first step in ameliorating this problem and working toward sustainable urban transformation in African cities is to understand the structures, systems and institutions in the city (UN-Habitat, 2010). One of such structures is the urban built environment.

The urban built environment comprises man-made features such as plazas, parks, buildings, roads and sidewalks, which are often created to accommodate car-centered urban transportation (Garfinkel-Castro et al., 2016). These features of the built environment are connected to urban health outcomes at micro, meso and macro levels (Garfinkel-Castro et al., 2016). Neighborhood design characteristics such as land use diversity, street connectivity, urban sprawl and neighbourhood walkability correlate with physical activity and active transportation (Garfinkel-Castro et al., 2016; Kurka et al., 2016; Sallis et al., 2015). Neighborhood features are also related to urban health outcomes such as hypertension (Malambo et al., 2016). Features such as land use mix, street connectivity, aesthetics, traffic, crime, the presence of infrastructure for walking and cycling, and perceptions of lack of safety from traffic are associated with self-reported hypertension (Malambo et al., 2016). Roadway design and land use development are related to pedestrian road traffic injury (Stoker et al., 2015).

Efficient and precise measurements of the quality and characteristics of urban neighbourhood are thus necessary (Harvey et al., 2015) as they can pinpoint specific neighbourhood variables to intervene on to make the city healthy and environmentally sustainable (Stoker et al., 2015). Neighbourhood audits are one of such tools for evaluating urban neighbourhoods that enable planning and improving urban built environment features for improved urban health (Babb et al., 2015). Audits can inform street design and subsequently changes to the urban form in order to encourage diverse and integrated transport and healthy behaviours (Barb et al., 2015). Based on information gathered from audits, recommendations for policy and practice can be made and used in transforming the built environment to make the city safe and sustainable (Schlossberg et al., 2015). Audits also build communities' capacities and understandings of neighbourhood issues thus enabling them to advocate for their health, sustainability and living conditions among city officials (Kemner et al., 2015). Audits are particularly useful for empowering community groups and planning agencies to assess neighbourhood design and its relationship to healthy behaviours (Sallis et al., 2015) given that audits are both valid and feasible to administer (Gullon et al., 2015).

Given the potential for neighbourhood audits to facilitate understandings of urban environmental health as well as community empowerment (Gullon et al., 2015), this study piloted an audit by (Brownson et al., 2004) in metropolitan Lagos, to understand built environment features in this setting and to yield recommendations for creating a healthy Lagos metropolis. The spatial spread of the metropolis is shown in Figure 1 below. The audit by Brownson et al. (2004) was administered in the United States and as such there is yet to be an understanding of how standard built environment features in high income

settings may differ from those in an African city like Lagos. This study aimed to add to global knowledge on built environments as they relate to urban health by adapting the auditing to the context of the Lagos metropolis and in so doing generate preliminary understanding on the characteristics of built environment which promote or militate against health in frontier settings such as this.

Figure 1: Lagos Metropolis (West, 2017)

It is particularly urgent to understand, intervene on and build community capacity in urban neighborhoods in contexts like Lagos. This is because metropolises in emerging contexts such as Lagos, Nigeria face growing built environmental pressures, which impact health negatively (Lawanson et al., 2015). Lagos is one of the most rapidly growing metropolises in the world (Clemans, 2015). Its population growth is approximately equivalent to the growth rate of its slums and is also related to urban poverty and urban inequities. In Lagos, poor urban neighbourhood characteristics are related to unhealthy lifestyles and poor health and psychosocial well-being (Idowu et al., 2016). Built environment factors are related to sanitation related diseases, and vary across neighbourhoods in Lagos (Lawanson et al., 2015).

Applying neighbourhood audits in understanding the urban built environment in settings such as Lagos is a needed first step that can inform measures to ensure urban built environment sustainability, a matter of urgency in African countries given resource constraints (GhaffarianHoseini et al., 2012). An audit of neighborhoods in this setting provides a tool for building community capacity, which is key to improving attitudes and outcomes to ensure sustainable transformation of communities in Lagos (Oghenekohwo et al., 2015). This project aimed to administer an auditing tool that has not yet been used in this setting to determine its utility and in order to inform practice.

In addition, this study applied a framework for assessing urban health and resilience from a holistic and ecological lens using the model in Figure 2. This model was formed from three different models namely the socio-ecological model (Bronfenbrenner, 1994), the social determinants of health model (Wilkinson et al, 2003) and the resilience framework of the Rockefeller Foundation (DaSilva et al, 2014). These three models were considered appropriate to the theory given that they frame the health of individuals as the function of multi-level factors that operate at the regional, local, and inter-personal levels. The socioecological model frames health as an outcome influenced by factors that operate across different scales such as political factors, economic factors, social and community factors (Bronfenbrenner, 1994). According to the social determinants of health model, health is a result of where people live, work and play (Wilkinson et al, 2003). The resilience framework views the city as a complex system whose ability to safeguard the health of its residents depends on factors that range from community empowerment to environmental stewardship, economy, service provision, leadership, security and planning (DaSilva et al, 2014). This project assessed how the built environment aspects aligned to the observable aspects of the framework namely environment, transport, civic participation and social networks, and integrated communities. It is hoped that this study will inform practice on how to characterize aspects of the built environment in the metropolis and to inform evidence-based efforts to integrate health and robust socioecological considerations into the sustainable planning of metropolises.

Figure 2: Conceptual Planning For Healthy And Resilient Cities

METHODS

Protocol for auditing and quality control of the audit

The study protocol was approved by the Institutional Review Board at the Colorado School of Public Health and the Human Research Ethics Committee of University of Lagos, Nigeria.

Outcome measure

The built environment was assessed using an analytic audit (Brownson et al., 2004). This audit was created based on peer-reviewed literature, expert input and digital information and characterizes features such as destinations, litter and graffiti, the presence of trees, sidewalk quality, public transit, recreational destinations, among others. While the audit had been found valid and reliable, it was tested in neighbourhoods in Missouri, United States. It was therefore crucial to assess its utility in Lagos, and to adapt it to this setting thus strengthening its global applicability in generating knowledge on built environments and urban health.

Study sample

The audit was administered in a purposeful sample of 72 street segments altogether. The audit was first of all piloted in 112 Road, Festac Town. Audit administration for the pilot took approximately 30 minutes and was carried out at noon. Additional questions had to be added to the existing questions based on observed features. For example, informal businesses were observed including petty traders, vulcanizers, clothes sellers, and nomadic tailors locally called “obiomas”. Other informal features included motorcycles locally called “okadas”, on-street parking, security guards locally called “mai guards”, formal security guards, informal transport buses known as “molues” and tricycles known as “keke napeps”. Noting differing maintenance levels, a question, “Are residences well-maintained?” was added. Likert scale responses with options of “none”, “a few”, “some” and “a lot” were used to note the condition of residences measured by features such as maintained paint, cleanliness and manicured greenery.

Covariates

The purposeful sample of 72 street segments sampled was classified into low, medium or high-income categories based on the income level that was predominant in the majority of the four wards in the local government. These income classifications were based on government classifications of income in each ward as documented by Nwokoro (2008). Altogether, there were six street segments sampled within each of the four wards in each of the three local government areas. Of these local government areas, Eti-Osa was predominantly high income, Ikeja predominantly medium income and the Ifako-Ijaiye predominantly low income.

Study procedures

Ratings were completed between 9am and 5pm each day with ratings arrived at through consensus. The principal investigator and two raters administered the audit to ensure consistency and with a secondary purpose of ensuring security. A day was set

aside when raters and the principal investigator walked through five neighbourhoods at random and piloted the audit. When there was at least 85% agreement between the raters, inter-rater reliability was confirmed and training completed.

Table 1 illustrates the sampling plan in detail. As the sampling proceeded, additions informed by field observations were made to the audit , leading to the final list of audit additions in Table 2. Community members sometimes approached raters to find out what they were doing during the observational process. In some cases, they commented on built environment issues, which were of concern to them. When this was the case, their comments were noted.

Table 1: Sampling Plan

Local Government	**Ward**	**Income Level**	**Number of enclosed residential units**	**Number of non-enclosed residential units**
Ifako-Ijaiye		**Aggregate: Low**		
	Ogba-Okeira	Medium	3	3
	Panada-Abule-Egba	Low	3	3
	Old Ifako-Karaole	Low	3	3
	Alakuko/Kollington	Low	3	3
		Aggregate: Medium		
Ikeja	Agidingbi/Omole/Ojodu	Medium	3	3
	Onilekere	Medium	3	3
	Adeniyi Jones/Ogba	Medium	3	3
	Onigbongbo/Military Cantonment	High	3	3
		Aggregate: High		
Eti-Osa	Obalende	Low	3	3
	Ilasan Housing Estate	Medium	3	3
	Victoria Island	High	3	3
	Ikoyi 1	High	3	3

Table 2: Questions added to the audit to account for informality and to enable context specificity

Presence of molue buses : None, a few (1-3), some (4-6), alot (>7)
Presence of okadas: None, a few (1-3), some (4-6), alot (>7)
Presence of informal/petty businesses (groundnut sellers, street retailers, phone card kiosks, etc): None, a few (1-3), some (4-6), alot (>7)
Presence of formal security people: None, a few (1-3), some (4-6), alot (>7)
Presence of informal security: None, a few (1-3), some (4-6), alot (>7)
Presence of hawkers (obiomas, bread and butter hawkers, newspaper vendors, etc): None, a few (1-3), some (4-6), alot (>7)
Presence of abandoned properties: None, a few (1-3), some (4-6), alot (>7)
Number of incomplete buildings: None, a few (1-3), some (4-6), alot (>7)
Presence of private bins: None, a few (1-3), some (4-6), alot (>7)
Presence of LAWMA (government) bins: None, a few (1-3), some (4-6), alot (>7)
Presence of keke napep tricycles: None, a few (1-3), some (4-6), alot (>7)
Trash overflowing from the bins or on the ground near the houses?: None, a few (1-3), some (4-6), alot (>7)
Gated buildings: None, a few (1-3), some (4-6), alot (>7)
Buildings fenced with barbed wire or electric fence: None, a few (1-3), some (4-6), alot (>7)
Buildings fenced with nails, broken glass or spiky rods: None, a few (1-3), some (4-6), alot (>7)
Was there power? Yes or No
Presence of generator sounds: None, a few (1-3), some (4-6), alot (>7)
Presence of noise pollution: None, a few (1-3), some (4-6), alot (>7)
Presence of private signs: None, a few (1-3), some (4-6), alot (>7)
Presence of government signs: None, a few (1-3), some (4-6), alot (>7)
Presence of business signs: None, a few (1-3), some (4-6), alot (>7)
The following questions were also adapted from the tool by Caughy et al () to account for social reactions and observations on the general maintenance of the neighbourhoods.
Are the residential grounds well maintained None, a few (1-3), some (4-6), alot (>7) Are the roads well maintained None, a few (1-3), some (4-6), alot (>7)

Data analysis and results

The built environment audit used for this study measures aspects of the built environment such as land use integration, variety of destinations (residential, recreational, commercial and government), natural features, active transportation, street characteristics (connectivity, lighting, signs), public amenities, aesthetics (comfort, noise, air pollution, physical disorder) and signage (Brownson et al, 2004). The audit was tested in St Louis, Missouri for 147 street segments that comprised high and low income neighborhoods (Brownson et al, 2004). Brownson et al (2004) found that the audit accurately found physical disorder for 67 of the low income segments and found no disorder in the high-income segments. Most of the 8 questions from each aspect of the audit had poor to moderate agreement (Brownson et al, 2004). The aspects of transportation and land use had high agreement and the aesthetic and social aspects of the environment were moderately to fairly reliable (Brownson et al, 2004). This demonstrates that the tool is reliable for capturing the features of the built environment particularly for the transport and land use aspects, and subsequently pinpointing areas where intervention is needed for urban sustainability,

Analytic approach

Analysis was conducted using SAS version 9.4. Audit data were transferred to excel and cleaned by recoding the variable names and formatting variables. Means, medians and standard deviations were calculated for continuous variables and percentages calculated for categorical variables. To determine the internal consistency reliability of the scale, a Cronbach's alpha was calculated for the whole scale and each sub-scale. To further test for the scale's reliability and validity, a pilot exploratory factor analysis was used to investigate the factor structure of the variable. A factor analysis was chosen to provide insight on which aspects of the neighbourhood environment tend to cluster together in metropolitan Lagos. Some aspects of the audit were not present at all in neighbourhoods or had a very low frequency such as being in one or two out of the 72 audited segments. These features were not included in the analysis on SAS. They include recreational facilities, natural features, provisions for walkability and bikeability, public transit stops, trails and service amenities.

RESULTS

Six continuous built environment factors in the audit were observable in this context: residential destinations, commercial destinations, public service destinations, street characteristics and recreational facilities. There was wide variation in these factors. The prominent features were residential destinations, followed by other destinations (abandoned buildings, vacant lots, driveways, parking lots and garages, and commercial destinations). Table 4 shows the Cronbach's Alpha computed for each of the six continuous built environment sub-scales. Below, these sub-scales and other categorical features observed are described.

Table 4: The Distribution Of The Subscales For The Continuous Built Environment Constructs

Category	Mean	Median	Minimum	Maximum	Standard Deviation	Standardized Cronbach's Alpha
Residential destinations	15.174	10	0	98	17.743	0.160417
Commercial destinations	3.638	1.0000000	0	33.142	6.966	0.386136
Public service destinations	1.986	1.6000000	0	11	2.277	0.336117
Other destinations	10.443	7.0000000	0	42	9.219	0.247821
Street characteristics	1.500	1.0000000	0	5.5	0.986	0.443168
Recreational facilities	0.0509	0	0	2.667	0.334	0.471810

Residential destinations

The residential destinations sub-scale measures types of homes and apartments in the segment. There were an average of 15 residential destinations per segment and this figure varied widely, having a range of 98. The Cronbach's Alpha for residential destinations was 0.160. Residential destinations accounted for 55.1% of variance in built environment factors.

Commercial destinations

Commercial destinations concerned features such as restaurants, super markets, hotels, offices and entertainment centers. On average there were 4 commercial destinations per segment with a range of 33. The Cronbach's Alpha was 0.386 for commercial destinations. Commercial destinations accounted for 7.33% of the variance in built environment factors.

Public service destinations

Public service destinations concerned features such as schools, hospitals, places of worship, government utility offices among others and were 2 per segment on average, with a range of 11. The Cronbach's Alpha was 0.336 for public service destinations. Public service destinations accounted for 17.3% of the variance in built environment factors.

Other destinations

Other destinations concerned parking lots, driveways, railroads, bridges, among others and this feature had an average of 10 per segment with a range of 42. The Cronbach's Alpha was 0.248 for other destinations, 0.443 for street characteristics and 0.472 for recreational facilities. Other destinations accounted for 50.79% of the variance in built environment factors.

Street characteristics

Street characteristics such as connectivity, traffic calming devices, aggressive driving, crossing aids, street lighting and features to reduce volume or speed such as roundabout scored low, an average of 1.5, with 1 being a little and 2 being some. The Cronbach's Alpha was 0.443 for street characteristics. Street characteristics accounted for 1.4% of the variance in built environment factors.

Recreational facilities

Recreational facilities concerned the presence of sports equipment or playground equipment. The recreational facilities sub-scale had a mean of 0.05. 97.2% of the segments had no available recreational facilities and 98.6% of the segments had no public recreational facilities. The Cronbach's Alpha for recreational facilities was 0.472. Recreational facilities accounted for 2.33% of the variance in built environment factors.

Other destinations

Other destinations concerned parking lots, driveways, railroads, bridges, among others and this feature had an average of 10 per segment with a range of 42. The Cronbach's Alpha was 0.248 for other destinations. Other destinations accounted for 50.8% of variance in built environment factors.

Transportation in the neighbourhood environment

Trails, paths, provisions for active transportation such as means for alternative transportation, walkability, bikeability and transit were missing in all segments. There were no sidewalks in 97.2% of segments. 100% of segments had informal on-street parking, 97.2% no marked lanes, 91.67% no traffic calming devices, 94.4% no streetlights and 98.61% no security warning signs.

Informal transport buses called "molues" were observed in 33.3% of the street segments and in 5.56% of the high-income segments. At least a few motorbikes also called "okadas" were observed in 55.6% of the segments with 38.9% in high-income segments. 54.4% of the segments had at least a few "keke napep" tricycles and this number reduced to 27.8% in low income segments. Half of the neighbourhoods had at least a few comfort features such as shade trees and benches. This number increased to 72.2% in high-income segments.

Aesthetics in the urban neighbourhood environment

The majority (83.3%) of the residences were at least a little well maintained while the majority of the roads (57.1%) were not well maintained. In high-income segments, only 16.7% of the segments had roads that were not well maintained. Over half of the segments (59.1%) had at least a few households with visible private bins whereas only 25% of segments had at least a few visible bins from the Lagos State Wastes Management Agency.

No graffiti was observed in 98.6% of the segments. Instead, physical disorder took the form of waste mismanagement. 48.6% of the segments had at least a little trash overflowing in the streets. This figure was much less in high-income segments

(22.2%). 44.4% of the segments had at least a few abandoned cars. There was a lot of garbage in 95.8% of the street segments and a lot of empty cans and bottles observed in 97.2% of the segments. 52.1% of the street segments had at least a few broken windows.

The majority (94.4%) of the segments had at least a little noise pollution with 52.78% having a lot of noise pollution. 65.3% of the segments had at least a little generator noise with 23.61% having a lot of generator noises. In low-income neighbourhoods, only 12.5% of the segments had a lot of generator noises. "At least a little noise pollution" was highest in the low income wards (95.8%) whereas the high income wards were most likely to have a lot of noise pollution (72.2%).

Signage in the urban neighbourhood environment

At least a few religious messages were observed in 62% of the total neighbourhoods and 27.8% of the high-income segments. In 21.1% of the segments, at least a few political messages were observed. 15.5% had at least a few neighbourhood messages and these took the form of funeral notices and information on opening and closing hours for neighbourhood gates. 48.06% segments had at least one private sign such as parking information, security warnings, house numbers and labels and information to deter fraudulent dispossession of landed property. This number rose to 88.89% in high-income segments. 71.73% of the segments had at least one government sign such as markings to indicate government certification or lack thereof, and signs from the government power authority as well as census markings. 91.43% of the segments had at least a few business signs visible.

The social environment in neighbourhoods

In 97.2% of the segments, at least a few people were visible and in 65.3% of the segments a few children were visible. In 42% of the segments at least a few children were seen walking. In over 90% of the segments at least a few teenagers or adults (between 13 and 65 years of age) were visible and were engaging were physically active behaviours, specifically walking. In line with the audit, raters looked to see if there were adults who were visibly aged and who seemed to be 65 years or older. This observation was notably limited by its subjectivity however there were much less people walking and/or visible in this category. Such older adults were observed in less than half (47%) of the segments and only in one-fifth (22%) of the segments were at least a few older adults engaging in physically active behaviours, specifically walking. At least a few people were seen talking in 83.33% of the segments and in 98.61% of the segments no arguing or fighting was observed.

Aggressive driving was determined by observing the road use of motorists to see if people were speeding, not obeying neighbourhood signs, having aggressive informal exchanges with other road users or intruding on the path of pedestrians. There were no observed aggressive drivers in 98.61% of segments. There were also significant informal transactions. There were at least a few hawkers seen in 38.89% of the street segments and at least a few petty traders observed in 66.67% of the street segments. There were no stray animals in 81.94% of the segments although domestic animals such as hens, turkeys and goats were often visible.

The prevalence of informality in the urban neighbourhood environment

Informality ranged from informal provision of goods and services, waste management and disposal, security provision, transport provision and on-street parking. Informal means of transport were more prevalent in low and medium income areas than in high income areas. For example, there were no molue buses in 94.44% of the high income segments versus 56.67% of the medium income segments and 58.33 % in the low income segments. There were at least a few okada motorbikes in 38.88% of the high income segments versus 70% of the medium income segments and 50% of the low income segments. There were keke napep tricycles in 27.78% of the high income segments versus in 53.55% of the medium income segments and 45.835% of the low income segments.

There were at least a few hawkers observed in 38.89% of the street segments. 66.67% of the street segments had at least a few petty traders. 59.11% had at least a few households with visible private bins as against 25% with at least a few LAWMA bins. 47.215% of the streets had at least a few informal security personnel as against 27.78% with at least a few formal security personnel. Compared to low-income areas, a greater percentage of high-income segments had informal security personnel (66.34% vs. 37.50%) and also had more formal security personnel (61.11% vs 20.83%)

Overall one third (33.3%) of the street segments had at least a few molues whereas only 5.6% of the high-income segment had at least a few molues. At least a few okada motorbikes were visible in 55.56% of the segments. This reduced to 38.88% in high-income segments. 54.44% of the segments had at least a few keke napep tricycles and this reduced to 27.78% in high-income segments. At least a few molues in 33.33% of the street segments. While there was no formal on street parking, all the segments had informal parking.

Power supply in the urban neighbourhood environment

Power supply, ascertained by asking residents if they had power, listening for generator noises which would indicate lack of power or looking to see lit bulbs, was absent in 67.19% of the street segments audited. In 65.28% of the segments at least a little sound from generators were heard while in 23.61% of the segments the generator sounds were very loud and thus categorized as a lot.

Security provision in the urban neighbourhood environment

Most streets had at least a few of their residences fenced with barbed wire and electric fences (77.78%) and broken glass, spiked rods and nails (86.11%). 47.215% of the streets had at least a few informal security personnel as against 27.78% with at least a few formal security personnel. There were more informal (66.34%) as well as more formal security personnel (61.11%) in high-income segments.

Residents' input

Residents who talked to raters shared security concerns owing to terrorism. Due to this recurring concern, raters started informing community members about the project before auditing in order to allay security concerns. Residents complained about poor roads, governance, flooding, waste management, environmental governance, drainage, political parties, fuel

scarcity, the rise of the dollar and the need to provide formal spaces for informal businesses. These complaints were consistent with the audit observations that the priority areas for interventions concerned physical disorder, waste management, governance and road infrastructure.

Table 3: The Exploratory Factor Pattern Of The Built Environment Constructs

Category	Sub-scale	Factor1	Factor2	Factor3
Integration of residential and non-residential land uses	Single family homes	0.07313	0.07675	0.84234
	Two, three, four, five or six family home	0.44300	0.05593	0.13633
	Apartment building/complex or condominium	-0.21043	-0.10429	-0.13075
	Apartment over retail in multi-story building	0.90799	-0.12037	-0.23597
Commercial destinations	Fast food restaurant	-0.11011	-0.02337	-0.07963
	Other restaurant	0.49305	-0.11264	-0.18875
	Warehouses	-0.02347	-0.01749	-0.16805
	Office building	0.10113	-0.01466	-0.04304
	Bar or liquor store	0.60354	0.02047	0.03326
	Other retail	0.86849	-0.08046	-0.21990
	Other services	0.42317	0.15961	0.51124
Public or government service destinations	Place of worship	0.33102	-0.03055	0.43699
	Daycare or preschool	0.24097	-0.10159	0.00775
	Elementary school	0.38694	0.01956	0.03046
	Middle, junior or high school	0.28096	-0.13925	-0.17821
	Health or social services	-0.08837	-0.08917	-0.09048
Other types of destinations	Driveway	0.09478	0.16644	0.51808
	Abandoned building or vacant lot	0.25258	-0.15773	-0.13942
Street characteristics	Connectivity	0.05589	-0.09510	-0.19015
	Traffic calming devices	-0.05248	-0.02275	0.16714
	Aggressive drivers	0.00000	0.00000	0.00000
	Street lighting	-0.13849	-0.07035	-0.18183
Facilities	Availability of public recreational facilities	0.12755	0.68942	-0.13945
	Availability of public recreational equipment	0.04595	0.97655	-0.15333
	Incomplete sports equipment	0.04595	0.97655	-0.15333

Exploratory factor analysis

Table 3 shows the exploratory factor pattern matrix for the built environment features. A 3 factor structure was found to be the best fit for the built environment features in the audited neighbourhoods. A cut-off of 0.4 was used for this analysis. In line with this, Factor 1 captured "apartment over retail in multi story building" (0.907), "other restaurant" (0.493), "bar or liquor store" (0.603), "other retail" (0.868), and "other services" (0.423). This factor was labeled "commercial services". Factor 2 captured "availability of public recreational facilities", "availability of public recreational equipment", "incomplete sports equipment" with loadings of 0.689, 0.976, 0.976 respectively. This factor was labeled "recreational facilities". Factor 3 captured "single family homes", "other services", "places of worship" and "driveway". This factor can essentially be called "residences and community services". Therefore, this pilot exploratory factor analysis results supports a 3 factor structure to describe the neighborhood environment in metropolitan Lagos. Specifically, commercial services, the recreational facilities and residences and community services appear to be the most salient environmental attributes of this environmental audit.

Limitations and strengths of the data collection process

An advantage of the data collection process is the use of stratified sampling which represented low, middle and high-income wards. This study also used a previously validated audit. There were limitations to the auditing process, one being its subjectivity. Perceptions of categorical variables and what constituted few, some and a lot are bound to differ. The study could have been affected by the time of the day. The team aimed to audit at a similar time period (around late morning to early afternoon) to minimize this limitation. An attribute such as power could only be gotten by either listening for generator noises or asking residents, or looking to see a lit light bulb. These ways of inquiring depended on observation and opinions.

Another limitation of the study is that it was not representative, rather a purposeful sample was used in administering the audits. However, given that this is a pilot study, the information can shed light on the appropriateness of this audit tool to measure the neighborhood environment in this area, thus enabling future representative studies to be context specific. In addition, there was no qualitative survey to contextualize the findings and understand what the built environment characteristics observed meant to residents. Passersby provided input on neighbourhood health challenges and this input was more preliminary than robust. Finally, another limitation was that the scale had not been previously validated or adapted for this area. However this is also a strength of this study given that its findings can contribute to a limited body of literature examining the urban built environment as it related to health and sustainable development in this context.

DISCUSSION

In line with Sustainable Development Goal 11, this project sought to understand and evaluate the built environment in neighbourhoods in metropolitan Lagos as a primary step in understanding how to ensure the sustainable development of the metropolis and similar contexts. An analytic audit by Brownson et al. (2004) was administered in a purposeful sample of 72 street segments, with this study assessing its utility in this context, adapting it to this setting while yielding information on built environment features in Lagos to advance knowledge and inform healthy urban development. Six continuous built environment factors in the audit were observed in this context: residential destinations, commercial destinations, public

service destinations, street characteristics and recreational facilities. There was wide variation in the number of each of these features per segment suggesting a lack of regularity in planning and creating neighbourhood features.

A possible explanation for this observation is that there are yet to be neighbourhood plans for the varying communities in Lagos (Heinrich Böll Stiftung Nigeria, 2016). The state government created a policy target of making neighbourhood plans available for each community by 2020 in the Lagos State Development Plan (Lagos State Government, 2016). When these plans are published, they will enable an assessment of the alignment of these neighbourhood features with the government's plans. Further studies may also wish to explore the governance mechanisms such as regulations, laws and fines used to align the neighbourhoods with the soon to be developed policy plans. The creation and enforcement of such plans could enable more proactive planning of neighbourhoods which could then make room for public health considerations.

Health promoting infrastructure in the neighbourhoods were missing. These ranged from recreational facilities to sidewalks, trails, paths, transit, street lights, security warning signs, traffic calming devices and crossing aids. These infrastructure are related to health behaviours and outcomes (Malambo et al., 2016; Sallis et al., 2015). In addition, they need to be supported by with the relevant signage. Currently, signage in neighbourhoods concerned private, business, political and religious purposes. Signs such as those promoting physical activity, road signs, pedestrian, bike or traffic signs and speed limits are needed for urban physical activity and health (Sallis et al., 2008).

The Lagos State government accords high priority to transport infrastructure, and this is reflected in their introduction of a bus rapid transit system and commencement of work on a light rail network (Heinrich Böll Stiftung Nigeria, 2016). However, most of the government's investments in transport including the road traffic law often focus on vehicular transport problems as against a more holistic approach to transport that centers the health of Lagosians (Heinrich Böll Stiftung Nigeria, 2016). This might be why there were tarred roads in the neighbourhoods but no provisions for healthy and safe transport infrastructure as detailed above. Finally, the majority of the roads were not well maintained, and this suggests a need for greater maintenance of roads at the neighbourhood level.

Some income variations were observed in the built environment features. High income areas had a greater prevalence of private signs, security personnel, comfort features such as shade trees and benches, a lot of generator noises, and a lot of noise pollution. Low income areas had a higher prevalence of poorly maintained roads, trash overflowing in the streets, religious signs and "at least a little noise pollution". This suggests that whereas high income areas may be at a public health benefit due to infrastructure and security, their purchasing power which enables them to own generators may then constitute a health problem in the form of noise pollution. Meanwhile, low income areas who may not suffer as much from the nuisance of generators would be at a health disadvantage due to poor maintenance of infrastructure, poor security, and poor waste management in their neighbourhoods.

The inverse relationship between "at least a little noise pollution" and aggregate ward income and direct relationship between "a lot of noise pollution" and ward income could be explained by the prevalence of generators in high-income areas due to

affordability. As a result, while low-income areas had more general noise pollution, high-income areas had less general noise pollution but more intense noise due to the specific pollution from generators. Access to power supply is needed especially given that generators contribute to noise and air pollution, and these sources of pollution affect health in African cities (Coburn, 2015). This would require improved power supply at the government level, and investment in making alternative and clean sources of energy such as biogas and solar energy affordable to everyday people. Lagos has a law to curb noise pollution (Lagos State Government, 2016), but would need to be more effectively enforced. However, the enforcement of the law may not necessarily yield the desired results except there is conscious expansion of power infrastructure and abundant delivery of non-fossil power to homes and businesses.

Another observation was that the provision of community services was insufficient at the neighbourhood level, with informal providers filling gaps in service delivery in areas of transport, security and waste management. The neighbourhood environment was mostly poorly maintained as signified by poor roads, abandoned cars on streets, and an abundance of garbage. Residents confirmed this observation; complaining about physical disorder, waste management, drainage, governance and road infrastructure. Communal aspects of the neighbourhood such as high neighbourhood disorder, poor waste management and inadequate road infrastructure impact negatively on health behaviours and outcomes (Ross et al., 2001). These observations raise the role for more governance of the communal neighbourhood domain as this domain was underserved by government resources such as waste management. Lack of participatory governance is a bottleneck that prevents resilience in services and urban infrastructure in African cities (Chirisa et al., 2016). Strategic plans for improving the city need to be supported by locally-relevant measures (Carmin et al., 2009), in this case measures that are relevant to the neighbourhood context. There is room for more research on how to build community ownership and participatory governance of the neighbourhood. In addition, future studies can explore how the government may support the informal arrangements for service provision and leverage them for urban public health.

Based on the exploratory factor analysis, the neighbourhood environment in metropolitan Lagos exhibits a three-factor structure with one factor capturing commercial services, the second capturing recreational facilities, and the third capturing residences and community services. Given that the Cronbach's Alpha for the built environment subscales was poor, they may not be internally consistent in Lagos. Rather, a separate audit specifically testing the reliability each of the three factors identified in the exploratory factor analysis may be more appropriate. It is hoped that the observed areas of need and the general characterization of neighbourhood features in this context will inform efforts to measure, improve and study metropolitan Lagos and similar cities in Africa in order to improve urban health.

CONCLUSION

Given the prominence of cities are the primary human habitation, it has become more urgent to ensure that they are resilient and safe, as is reflected in goals 11 and 9 of the sustainable development goals which concern building resilient infrastructure and making cities safe, inclusive and resilient respectively (United Nations, 2016; Opoko et al., 2014). This research project aimed to adapt and apply a neighborhood built environment audit (Brownson et al., 2004) to street segments in metropolitan

Lagos as a primary step in characterizing the city and understanding priorities for sustainable and healthy urban development. The audit process offers a potentially affordable and accessible way to understand the built environment and use this information to inform the design of interventions that address urban African neighborhood contexts like Lagos (Clemans, 2015, Oghenekohwo et al., 2015). The key observations of this study were that residential, community and commercial purposes were the main forms of land use in urban neighbourhoods in metropolitan Lagos. Physical disorder, power supply, waste management, governance and road infrastructure were identified as priority areas for urban health interventions.

In this context, there are high levels of informality in service provision, security provision, transport, parking and waste management. This study has provided a guide for future auditing efforts on what informal features to take note of. Neighbourhood residents were often seen walking and engaging in utilitarian physical activity and this pro-social interaction could be a resource for building social capital in the neighbourhood, especially given the observation that communal domains of the neighbourhood are both under-serviced by the government and not catered to by individuals. Residential buildings were often in good condition while communal neighbourhood domains especially regarding physical disorder, waste management, drainage and road infrastructure were in dire need of improvement. This also demonstrated that the demand for government services such as drainage, sanitation and transport was still greatly in excess of its supply in neighbourhoods and that the communal domain of the neighbourhood is a key intervention area for improving urban and neighbourhood health.

Finally, active transportation including provisions for walkability, bikeability and transit were entirely missing in most neighbourhoods. While there were already many residents engaging in utilitarian travel in neighbourhoods, investments in active transportation will help the ensure their safety. Given the relationship between the neighbourhood features and health behaviours such as walking as well as health outcomes such as hypertension and injury (Garfinkel-Castro et al., 2016; Kurka et al., 2016; Sallis et al., 2015; Malambo et al., 2016; Stoker et al., 2015), features and signs to promote active transportation may also improve recreational physical activity. This potential for safe utilitarian and frequent recreational physical activity can help to improve health outcomes while reducing the risk for injury.

The neighbourhood environment could generally be described as pro-social, with people often walking and interacting on the streets. There were no aggressive drivers in most of the neighbourhoods and no people observed arguing or fighting. In addition, neighbourhood disorder took the form of poor sanitation rather than vandalism. Future studies may wish to explore these pro-social neighbourhood behaviours as a potential resource for building community capacity and governance of the urban neighbourhood.

The locus of this study bears the most relation to the local and neighbourhood levels of the conceptual model in Figure 1. Observable aspects of the environment reflected constructs of this model such as environment, housing, transport, civic participation and social networks. Given that this study was observational in nature, it focused on observable features of each of these aspects of the built environment such as the aesthetics of the environment, types of housing, varieties of transport options available and social interactions in the neighbourhoods. However it lacked the specificity to address the specific

aspects of each construct, such as membership of local organizations, varieties of social support and trust, under the "civic participation and social networks" construct.

Future studies will be needed to validate this framework, making use of quantitative tools to assess these constructs, especially those that cannot simply be ascertained through observation. Future research will also need to test the specific pathways and the measurement of the latent constructs of the model to understand the relationships between these multi-level factors and health in Lagos. There is also room for future research to test the findings of this study in various cities across Nigeria and Africa to yield a standard set of built environment constructs that are adapted to this region. A purposeful sample was used for this study, so while it was not representative it accounted for spatial and income diversity in the metropolis and provided a starting point for future studies that may have the resources to use a representative sample. That notwithstanding, these observations provide starting points for understanding the features of urban built environment in metropolitan Lagos, auditing similar urban contexts and identifying the key areas where interventions should be targeted in metropolitan Lagos.

Based on the exploratory factor analysis, the neighbourhood environment in metropolitan Lagos exhibits a three-factor structure with one factor capturing commercial services, the second capturing recreational facilities, and the third capturing residences and community services. Given that the Cronbach's Alpha for the built environment features was poor, this suggests that the six neighbourhood features may not be internally consistent in Lagos and rather a separate audit specifically testing the reliability each of the three factors may be more appropriate. It is hoped that the observed areas of need and the general characterization of neighbourhood features in this context will inform efforts to measure, improve and study metropolitan Lagos and similar cities in Africa in order to improve urban health and ensure progress toward the sustainable development goals.

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