SOCIO-SPATIAL ANALYSIS OF SMALL-AREA NEED AND ACCESSIBILITY OF PRIMARY HEALTHCARE SERVICES IN NIGERIA: A SEQUENTIAL MIXED METHODS STUDY

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Abstract

Accessibility of primary healthcare (PHC) services is crucial for maintaining the good health of a population. Not only is health(care) associated with quality of life and socioeconomic productivity, systematic variations in healthcare accessibility are matters of social justice. Consequently, the overall goal of this project is to comprehensively analyze and explain small-area need and accessibility of PHC services in Nigeria through a case study of Kogi State, with a view to making policy-relevant recommendations. To this end, both quantitative and qualitative methods are synthesized in an 'explanatory sequential mixed methods research design', which also features innovative data exploitations. This entails a synergy of: Automated Zone Design method, Spatial Microsimulation Modelling, and Generalized Two-Step Floating Catchment Area method for quantitative analysis as well as qualitative framework thematic analysis, to obtain research findings that are more robust than existing studies. In this way, genuine small-area variations in PHC need and accessibility are revealed and explicated, including extreme Medically Underserved Areas (eMUAs). Urban areas are more accessible than rural areas, as expected. Of senatorial districts, Kogi Central has the best healthcare accessibility because of its topography. Furthermore, these variations are mediated by the extant sub-optimal zoning system in Nigeria, which is a product of problematic historical political processes. Not only are eMUAs both very remote and rural, they also lack basic social amenities. Hence, it is not surprising that research participants expressed a myriad of dire disincentives in meeting their PHC needs. These difficulties can be mitigated by improving the quality of road infrastructure and ensuring an optimal socio-spatial configuration of PHC services. Broad mechanisms of social exclusion are also implicated in causing access-related disutility of PHC. It is therefore crucial that holistic interventions to alleviate social exclusion are enacted, since previous efforts at addressing only proximal concerns of PHC accessibility have proven unsuccessful.

Keywords: Primary Healthcare Needs, Spatial Accessibility, Mixed Methods Research, Automated Zone Design, Spatial Microsimulation, Small-Area Variations.

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2SFCA	Two-Step Floating Catchment Area
ACT	Artemisinin-based Combination Therapy
AED	Absolute Entropy Difference
AIDS	Acquired Immunodeficiency Syndrome
ANC	Antenatal Care
BBA	Building Block Area
CHEW	Community Health Extension Worker
CHS	Child Health Service
CO	Combinatorial Optimization
CPE	Cell Percentage Error
CS	Caesarean Section
CSDH	Commission on Social Determinants of Health
CWPI	Cadre-Weighted Personnel Index
DHS	Demographic and Health Survey
E2SFCA	Enhanced Two-Step Floating Catchment Area
EA	Enumeration Area
EHP	Essential Health Package
eMUA	extreme Medically Underserved Area
FGD	Focus Group Discussion
FMF	Flexible Modelling Framework
FMoH	Federal Ministry of Health
G2SFCA	Generalized Two-Step Floating Catchment Area
HIC	High Income Country
HIV	Human Immunodeficiency Virus
HPSA	Health Professional Shortage Area
IDSO	Index of Disparity in Service Opportunities
LGA	Local Government Area
LMIC	Low- and Middle-Income Country
MAUP	Modifiable Areal Unit Problem

MDG	Millennium Development Goal
MHS	Maternal Health Service
MICS	Multiple Indicator Cluster Survey
MLR	Mixed Level Regionalization
MUA/P	Medically Underserved Areas/People
NGO	Non-Governmental Organisation
NHP	National Health Policy
NMIS	Nigeria MDG Information System
NN-M2SFCA	Nearest Neighbour-Modified 2SFCA
NPHCDA	National Primary Health Care Development Agency
NSHDP	National Strategic Health Development Plan
ONN-G2SFCA	Optimized Nearest-Neighbour Generalized 2SFCA
PE	Percentage Error
PHC	Primary Healthcare
PPR	Provider-to-Population Ratio
PROGRESS	Place of residence, Race or ethnicity, Occupation, Gender, Religion, Education, Socioeconomic status and Social capital or resources
RAAM	Rational Agent Access Model
REDCAP	Regionalization with Dynamically Constrained Agglomerative Clustering and Partitioning
RMSE	Root Mean Square Error
SAE	Small-Area Estimation
SAV	Small Area Variation
SBA	Skilled Birth Attendant
SDG	Sustainable Development Goal
SIM	Spatial Interaction Model
SMM	Spatial Microsimulation Modelling
SMMR	Spatial Mixed Methods Research
SPAI	Spatial Accessibility Index
SPAZ	Spatial Accessibility Z-Score
SSD	Sample Survey Data

TAE	Total Absolute Error
TCAM	Traditional, Complementary and Alternative Medicine
TE	Total Error
UGCoP	Uncertain Geographic Context Problem
UHC	Universal Health Coverage
UN	United Nations
UNICEF	United Nation International Children's and Education Fund
V2SFCA	Variable 2SFCA
WHO	World Health Organization
WHS	Ward Health System

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Chapter 1. Introduction

1.1 Background

Benjamin Disraeli's assertion that 'the health of the people is the foundation upon which all their happiness and all their powers as a state depend' holds true in contemporary times (Evans *et al.*, 2001, p. v). Thus, healthcare is probably the most basic of all services because it determines the survival rate of new-born children, and also, determines if victims survive accidents and whether they become handicapped as a consequence (Smith, 1979, p. 246; National Research Council, 2010). Hence, throughout the world, the definition and measurement of accessibility are critical to the planning, funding, and implementation of programs to improve healthcare delivery, in assessing equity in healthcare provision and service utilization patterns, and in evaluating health outcomes, since spatial variations in levels of morbidity and mortality will also show differences in healthcare accessibility (Cromley, 2009; Humphreys and Smith, 2009; Mary and Toussaint, 2009). Indeed, good health is a prerequisite for longevity, quality of life, optimum functioning and sexual attractiveness (Bowling, 2014b, p. 37; Cockerham, 2017, p. 171). In addition to ensuring a high quality of life of a population, investments in healthcare are important aspects of human capital investments because improvements in health are known to have major positive effects on economic growth and development (Mayer, 2001; Szirmai, 2005). For instance, with poor health comes a reduction in both the number of hours a person can work per year as well as a person's motivation. Malnutrition and illness result in decreased body weight, human energy and productivity, such that unhealthy and undernourished people are lethargic, listless and passive (Dillon *et al.*, 2014). Consequently, malnourished or ill people tend to be constrained to choosing less productive work with lower incomes, which typically require less energy and effort. Furthermore, learning potential decreases with illness, making investments in human capital development and education less attractive. Hence, many health-related goals/indicators are featured in the Millennium Development Goals (MDGs) (UN Millennium Project, 2005; Richard *et al.*, 2011); the Sustainable Development Goals (SDG) (United Nations (UN), 2015); and the Human Development Index (HDI) (Jāhāna, 2015). It is therefore not surprising that health(care) also features prominently in development studies (Chant and McIlwaine, 2009, p. 255; Potter *et al.*, 2018, p. 227). Although ensuring an optimal spatial accessibility of healthcare services does not solely translate into effective healthcare provision for a population, it is a necessary foundation (Eyles, 1990; Levy and Meltzer, 2004; Campbell *et al.*, 2014).

Health geography is one of the burgeoning specialties of human geography with researchers being interested in either of two main branches; namely: spatial epidemiology or health services research (Joseph and Phillips, 1984; Gesler, 2004; Foley *et al.*, 2009, p. 74; Dorn *et al.*, 2010). Spatial epidemiology studies the distribution of disease in geographical space, with a focus on morbidity and mortality (Mayer, 2010; Bowling, 2014a; Gatrell and Elliott, 2015b, p. 8). Health services research is a multidisciplinary field that focuses on the accessibility, quality, cost and outcomes of healthcare with a view to improving its efficiency, equity and effectiveness mostly by influencing and developing public policies (Mullner, 2009). Succinct discussions on the evolution of health services research in Geography, including its theoretical foundations abound (Barnett and Copeland, 2010; Gatrell and Elliott, 2015a). Extensive theoretical and empirical discussions of Geographical Information Systems (GIS) applications in health services research are also documented (Cromley, 2009; Cromley and McLafferty, 2012; Davenhall and Kinabrew, 2012). Operations researchers and spatial planners in health are keen on solving complex decision-making problems, including those that involve the spatial dimensions of health service planning (Rahman and Smith, 2000; Doerner *et al.*, 2007; Thomas, 2007; Curtis and Scheurer, 2010). Among other things, the current study which is most situated in the health services research strand of health geography provides a solid analytical foundation for optimizing the spatial re-organization and/or expansion of PHC services in the study area, in line with rich traditions of spatial analytics in healthcare (Gesler, 2004, p. 494). In so doing, relevant aspects of spatial epidemiology are invoked (especially in Chapter 5 and parts of Chapter 6) to the extent that these are inevitable for analyzing spatial accessibility (Foley *et al.*, 2009, p. 75; Dorn *et al.*, 2010; Kearns and Collins, 2010, p. 26).

The concept of access to healthcare is complex and multidimensional and encapsulates accessibility (Gulliford *et al.*, 2002; Cabieses and Bird, 2014), thus it has attracted the attention of multiple disciplines and resulted in several conceptualizations, models and theories of access (Cabieses and Bird, 2014). Even though it is important for every country to achieve equitable access to healthcare, the exceptionally higher burden of healthcare needs that coincides with the dire under-resourced healthcare systems in Low- and Middle-Income Countries (LMICs) makes this challenge particularly daunting in these countries (Joshi *et al.*, 2008; Ozegowski and Sundmacher, 2012). The greatest barriers to healthcare access are often experienced by the most vulnerable population groups in the majority of LMICs (Willis-Shattuck *et al.*, 2008; McIntyre *et al.*, 2009), and this is compounded by studies that demonstrate that an overall improvement in access to healthcare in a country does not always translate to enhanced access for such groups (Victora *et al.*, 2000; Stafford *et al.*, 2008). The term 'inverse equity hypothesis' has been used to describe a situation whereby new health interventions reach the socioeconomically advantaged groups before the poorer majority are able to benefit. Children, the poor, ethnic minority groups, women and other groups that suffer discrimination and/or stigmatization are vulnerable groups that are most affected by poor access to healthcare in societies. This disparity in the diffusion of healthcare interventions that further privileges well-off population subgroups is common in LMIC. While the MDGs explicitly set out to improve access to healthcare as one of its targets, the subsequent SDGs target elimination of inequalities in healthcare access (UN Millennium Project, 2005; UN, 2015). Effective geodemographic targeting at both the demand- and supply-sides of healthcare, which is one of the overarching policy orientations of the current thesis, is the recommended strategy for achieving this in LMICs (Victora *et al.*, 2003; Ashford *et al.*, 2006; Bornemisza *et al.*, 2010; Rahman and Wazed, 2018).

The general level of development of a country, the type of healthcare system available, the geography and demography of a country, population beliefs and values about (ill) health and other wider issues are all very interrelated to healthcare access (Cabieses and Bird, 2014). In making a strong case for developing their framework and glossary for understanding healthcare access in LMICs such as the current study area, Cabieses and Bird (2014) highlight four key differences between LMIC and high-income contexts. The first is their epidemiological and demographic peculiarities; the second is that the significant resource constraints of their overall healthcare systems go beyond their financial limitations to include other areas of deficiencies in human resources and infrastructure (Kuehn, 2007). Third, LMIC's healthcare systems often have multiple actors with multiple (sometimes conflicting) priories that influence the provision, access and equity of healthcare service (Suraratdecha *et al.*, 2005; Meda *et al.*, 2010). Such actors include international organizations, national governments and private sectors. Lastly, oppressive political systems, economic instability and poverty, conflict and constant changes of political leaders are some examples of the multiple socio-political problems confronting LMICs with debilitative effects on their systems (Roberts and Browne, 2011). Furthermore, within and between LMICs, there is a great diversity in sociocultural and geographic contexts as well as differences in economic policies and development contexts, which ought to be adequately accounted for. Hence, in addition to being context-sensitive, the current study comprehensively analyzes social and spatial facets of primary healthcare need and accessibility at multiple spatial scales, starting with an optimized small-area scale. At the same time, relevant sociocultural differences are discursively accounted for.

Despite arguments over the meaning of equity, it is well established in liberal and social democratic philosophy that equity is an appropriate criterion for healthcare delivery (Joseph and Phillips, 1984; Evans *et al.*, 2001; Gatrell and Elliott, 2015a). Health inequalities were recently described by one government minister in Britain as ‘the most important inequalities of all’ (Dorling *et al.*, 2009, p. 46). Therefore, health geographers are interested in the socio-spatial dimensions of equity as it relates to the accessibility and utilization of various kinds of health and social care (Eyles, 1990; Curtis, 2004). ‘Underserved’ populations and places have received sustained attention from geographers who attempt solutions by calculating the most equitable spatial allocations of healthcare. Their goal is to reach some sort of ‘territorial justice’ such that healthcare needs are equally met everywhere by an appropriately proportioned amount of resources (Meade and Emch, 2010, p. 428).

Health inequalities persist in many countries even when some have implemented several interventions in health financing and social health protection (Popay *et al.*, 2008b). Hence, there is a pressing need for health equity intervention research in contemporary times, especially in LMICs like Nigeria (Commission on Social Determinants of Health (CSDH), 2008; World Health Assembly, 2009, 2012, 2013; WHO, 2011, 2013a). Health equity research develops innovative methods and/or utilizes existing evidence and methods to address the determinants and disparities of health and healthcare inequalities. Disparities in health(care) are characterized using relevant disaggregated data to: understand the relationship between the drivers and outcome of health(care) inequalities, quantify the impact of relevant policies on population subgroups or evaluate the effectiveness of policy outcomes (Health Inc Consortium, 2014). Consequently, 'Equity Stratifiers’ denoted by the acronym PROGRESS (which stands for Place of residence, Race or ethnicity, Occupation, Gender, Religion, Education, Socioeconomic status and Social capital or resources) is the internationally adopted data disaggregation framework for studying health(care) equalities (Gwatkin, 2007; CSDH, 2008; WHO, 2013a). While practical tools for assessing health inequalities are few, a necessary condition in order to resolve this challenge is for health systems to be people-centred and effective (Health Inc Consortium, 2014). Being equity-sensitive, the current study not only disaggregates data according to relevant socio-spatial dimensions, particularly small-area geographies, but is also people-centred.

1.2 Statement of Research Problem

Not only is the paucity and maldistribution of healthcare services in Nigeria is well-known, these have also become worse in recent times (Humphreys and Smith, 2009; Federal Ministry of Health (FMoH), 2018). Many of these problems which are well-documented in relevant official publications are persistent. Key documents in this regard include: Nigeria's National Human Development Report, 2016 (UNDP Nigeria, 2016), the National Health Policy (NHP) (FMoH, 2016, p. 8) and the National Strategic Health Development Plan 2018 – 2022 (NSHDP II) (FMoH, 2018). For instance, the NHP notes that many health facilities are situated far away from the people, especially in rural and hard-to-reach areas (FMoH, 2016, p. 88). According to the NSHDP for 2010 - 2015, healthcare delivery in Nigeria is characterized by the following challenges: inequitable distribution of resources, decaying infrastructure, poor management of human resources for health, poor accessibility of high-impact cost-effective interventions, unavailability of essential drugs and other commodities, and so on. Thus, there is a deficiency of primary healthcare services in the country, especially at the ward and LGA levels (FMoH, 2010, p. 33). Furthermore, not only does Nigeria currently suffer a significant and chronic shortage of healthcare workers for its population needs, there is also a staggering mal-distribution of available healthcare personnel to the disadvantage of rural areas, northern regions and primary healthcare facilities (FMoH, 2010, p. 38; 2018, p. 47). This is exacerbated by the difficulty of deploying (and retaining) healthcare personnel to rural areas due to a lack of institutionalized motivation and retention mechanisms and other contextual disadvantages, despite the relatively high disease burden in these contexts. Indeed, the problems of poor and disparate PHC accessibility in Nigeria are not new. For example, a comprehensive discussion of the fundamental bases for health(care) paucity and inequality in Nigeria is provided by Ityavyar (1985, 1987, 1988) who succinctly analyze the growth and development of healthcare services from 1960 to 1988 and discuss the various spatial patterns and trends of inequalities in access to and use of healthcare services.

Hargreaves (2002) also explains the precarious situation of health services' coverage in urban slums of Nigeria, stressing that scarce funds (including those from donor agencies) are poorly managed, thereby perpetuating the health service challenges of the country. Similarly, Akhtar

(1991) blames the paucity and inequality in the spatial coverage of healthcare services on the government's poor and unfair budgetary allocation and spending. Akhtar (1991) observes that healthcare in Nigeria is influenced by different local and regional factors that affect the quality or quantity present in various localities; therefore, Nigeria's healthcare system shows spatial variation in terms of availability and quality of facilities in relation to need. This, according to Akhtar (*ibid*) is caused largely by the level of government's involvement and investment in healthcare programs and education. For instance, 70% of Nigeria's ministry of health budget is usually spent in urban areas where about 50% of the population lives. Geographic variations in healthcare will likely continue in the future because of the uneven and continuously changing distribution of disease and healthcare providers across the nation. Even though there will always be geographic and regional differences in the care that patients receive; it is systematic variations in healthcare access and the subsequent clinical and statistical significance of disparities in health that are of concern (Maeda, 2009). It is therefore not a surprise that there remain remarkable dearth and inequality in the socio-spatial coverage of healthcare services of Nigeria, with many observing the situation to be deteriorating (Humphreys and Smith, 2009; UNDP Nigeria, 2016; FMoH, 2018). Recent documentations of the dire problems of healthcare services in Nigeria abound, reiterating the foregoing concerns and more (Efe, 2013; Wollum *et al.*, 2015; Uzochukwu, 2017, p. 17). However, there remains limited understanding of the small-area socio-spatial details and the mechanisms of these healthcare problems. As a result, current policies, plans and strategies for mitigating these problems are of limited effectiveness and sustainability as discussed further in Section 1.5.2 and explicated throughout this thesis. Kogi State which is the specific study area for micro-level analyses in this research is in the middle belt region of Nigeria, and serves as a microcosm of the entire country as discussed further in Section 1.5.1.

Recent works on health services research in Nigeria have focused mainly on Maternal, New-born, and Child Health (MNCH) services (Adewemimo *et al.*, 2014; Garba and Bandali, 2014; Gayawan, 2014; Abegunde *et al.*, 2015; Agboghoroma and Gharoro, 2015; Ashimi and Amole, 2015), probably because of the renewed emphases in MNCH as underscored by the SDGs and other partner development initiatives (Kuruvilla *et al.*, 2016). These studies do not consider spatial dimensions of access, but rather have been more focused on predisposing and need-based factors. In addition to showing the relationship between physical health facilities provided by the public and private sectors in Nigeria, Ingwe (2012) underscores the need for further studies that use geodemographic and spatial analyses to inform policies for scaling up and/or reconfiguring healthcare services. The need for small-area analyses using disaggregated data is specifically highlighted because most existing works are based on data aggregated at coarse spatial scales. In this regard, it has often been shown that national aggregate data mask/conceal substantial subnational spatial variations/disparities in both the provision and utilization of healthcare, including in Nigeria (Johnson *et al.*, 2010; Sridhar, 2016; UNDP Nigeria, 2016, p. 61; Cuadros *et al.*, 2017). Consequently, evidence from research conducted at the national level tend to be inappropriate for policy making and intervention at state and local levels. Among other things, the current thesis fills these knowledge gaps, as outlined in the next section.

1.3 Aim and Objectives

In light of problems discussed in Section 1.2 above, the overall goal of this doctoral research project is to comprehensively analyze small-area need and accessibility of primary healthcare services in Nigeria through a case study of Kogi State, with a view to discursively exploring people's experiences and perspectives in extreme Medically Underserved Areas (eMUAs). To this end, the objectives of this study are:

1. develop a synthetic small-area zoning system that is optimized for the current study;
2. derive some small-area estimates of primary healthcare needs, which are also consonant with standard health-related development indicators;
3. analyze small-area variations in spatial accessibility of primary healthcare services;
4. explore the discursive experiences, perceptions and perspectives of healthcare access in eMUAs.

These objectives are elaborated further in Section 3.3 as well as in related empirical chapters (i.e. chapters 4 to 7). The next section summarizes the importance of both good health status and improved access to primary healthcare services in order to further foreground the salience of this research project.

1.4 Significance of the Study

Descartes, a philosopher of the 17th Century, aptly asserts that health preservation is the first good and the foundation of all other goods (Anand, 2004, p. 17). Healthcare has also been attributed moral importance by Daniels (1985), who extends Rawls' principle of Fair Equality of Opportunity (FEO) to healthcare (Rawls, 1999). Based on this principle, it has been argued that as part of protecting the range of opportunities that individuals can reasonably exercise, it is of moral necessity to maintain the health of a population. Similarly, the capability theory (Sen, 1985, 2005) supports the notion that health(care) is a special commodity/service because of its role in positively influencing wellbeing/health. In addition to emphasizing the fundamental benefits of health to individuals, societal importance is buttressed by the capabilities approach. This is premised on the idea that to fully engage in political processes, provide for societal security and defence as well as assure economic prosperity and generate wealth, a minimum level of health is necessary (Gostin *et al.*, 2016, p. 8). Similarly, Dwyer (2010) rightly explains that in order to enable people to engage in the social activities that are of central importance to human development, the provision of basic healthcare is an essential prerequisite, with Daniels (1985) asserting that healthcare is a right because it assures equality of opportunity. It suffices to say here that because of its societal perspective, the capability approach is invaluable in supporting the development of social policies and for the empirical solutions to actual policy problems, including healthcare access considered in the current thesis (Da Costa Leite Borges, 2016a).

It goes without saying that inasmuch as primary healthcare services are crucial to maintaining and/or restoring the good health of a population, their accessibility is invaluable in every context, including the study area. The primary motivation for accessibility studies in geography is to offset the distance-decay effect as much as possible. Distance-decay suggests that with greater distance to healthcare facilities comes less likelihood of services' utilization (Ambery and Donald, 2000; Hippisley-Cox and Pringle, 2000; Field and Briggs, 2001; Reilly *et al.*, 2001), as well as increased socio-spatial inequalities in health status (Hewko *et al.*, 2002; Haynes, 2003). Improved accessibility therefore results in enhanced healthcare utilization, with the effect that overall population health status is improved. The notion of a distance-decay effect has been expanded into considerations of access beyond the narrow remits of spatial distance, to incorporate every facet of utilization-related impediment. In this regard, disparities in access are shown to affect healthcare utilization as well as health outcomes, such that with lower accessibility comes a reduction in utilization by needy populations (Dai, 2010; Bissonnette *et al.*, 2012). The implication is that preventive, chronic, or acute care is usually foregone when facilities are far away and/or costly and cumbersome to reach – a common experience in rural communities the world over (Peters and Gupta, 2009). Furthermore, with regular and timely utilization of primary (preventive) care comes a reduction in the need for acute care. Since the untimely (i.e. delayed) and irregular utilization of PHC services are associated with poor accessibility, the adverse effects of poor accessibility on health status are apparent. To this end, health geographers are at the forefront of developing, advancing, and implementing geographical methods of analyzing healthcare accessibility. Health geographers are also adept at explicating the spatial dimensions of healthcare accessibility, by applying relevant socio-spatial theories across post-positivist and interpretive theoretical fields.

A cardinal motivation for the current study is that "in the developing world research should focus on the generation of more locally relevant and precise estimates of geographical access and their relationship to health outcomes" (Tanser *et al.*, 2010, p. 560). With spatial analysis of primary healthcare accessibility at optimized small-area zones comes the challenge of robust small-area estimates of the basic healthcare needs of a population. This may not be so much of a challenge in High-Income Countries (HICs), which are able to collect and publish micro-level census records or individual/household survey data, albeit at a high expense of cost and time (O'Donoghue *et al.*, 2014). Nevertheless, even in HICs, detailed information on health-related indicators are increasingly required by healthcare services and local policy makers at smaller geographical scales (like districts or neighbourhoods), as part of efforts at decentralizing the social policy domain (van de Kassteele *et al.*, 2017). The difficulty of estimating health-related indicators for small-area zones is pervasive; hence, the decentralization aspirations of public health activities are often constrained to monitoring and target-setting at relatively crude geographic scales (i.e. coarse or large zones) (*ibid*). Furthermore, robust spatially referenced micro-level or small-area population data is increasingly important for analyzing the geographical impact of government policies as well as public and private investments (Ballas and Clarke, 2009). This is because small-area data, which the current study develops, makes it possible to show more detailed and finer-grained spatial patterns than can be revealed with large-area data, thereby resulting in better insights from research works (Cromley and McLafferty, 2012, p. 132; Goodman and Goodman, 2017).

There is further elaboration on the rationales for small-area estimation of primary healthcare needs and accessibility in Section 2.2.3. In the next section, the study area is discussed, including current policies relevant to primary healthcare access in Nigeria.

1.5 The Study Area and Policy Context

1.5.1 The Study Area: Kogi State, Nigeria

Administratively, Nigeria is principally divided into thirty-six (36) States (including the Federal Capital Territory (FCT)). As shown in Figure 1-1, a group of five (5) or six (6) contiguous states constitutes each of the six geopolitical zones in the country, namely:

1. **North Central:** Benue, Kogi, Kwara, Nasarawa, Niger, Plateau, and the FCT
2. **North East:** Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe
3. **North West:** Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara
4. **South East:** Abia, Anambra, Ebonyi, Enugu, and Imo
5. **South South:** Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers
6. **South West:** Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo

Nested within States are a total of 774 LGAs within which there are also a total of 9,555 wards in Nigeria. Figure 1-2 is a schema of the administrative structure of Nigeria. Whereas geopolitical zones serve no administrative functions, states are governed/administered by a Governor, while LGAs are governed by a Chairman. Wards serve legislative functions of which a ward is represented by a Councillor who is a legislator at the Local Government Area (LGA) administrative level. A contiguous collection of wards forms a State Constituency, with each state having 24 to 40 state constituencies. Each state constituency produces a legislator for the state government, known as a 'House of Assembly' member. LGAs are primarily subdivided into wards, which in turn form the state constituencies. States are principally subdivided into LGAs. A contiguous collection of LGAs forms the 'federal constituencies' and the 'senatorial districts', which are lower and upper legislative arms, respectively, to the federal/national government. A legislator representing a federal constituency is called a 'Member of the Federal House of Representatives', while a legislator representing a senatorial district is called a 'Senator'. The foregoing administrative structure of Nigeria is illustrated in Figure 1-2 which shows that settlements (i.e. hamlets, villages, towns and cities) are contained within wards, but some large settlements may span more than one ward. In order words, some large settlements may be divided into multiple wards. The average size of wards is generally larger than the Census Enumeration Area geography; consequently, most settlements are subdivided into multiple census enumeration areas. A census enumeration area is exclusively a statistical aggregation geography for population census enumeration.

The 2006 national population census shows that Nigeria had a population of 140,431,790 (comprising 71,345,488 males and 69,086,302 females) (National Population Commission (NPC), 2010). Of this, the population of Kogi State was 3,314,043 (made up of 1,672,043 males and 1,641,140 females). By 2016, the official population estimate of Nigeria was 193,392,517 (comprising 94,762,333 females and 98,630,184 males) (National Bureau of Statistics (NBS), 2020). Of this, Kogi State was estimated to have a population of 4,473,490 (of which 2,192,010 are females and 2,281,480 are males).

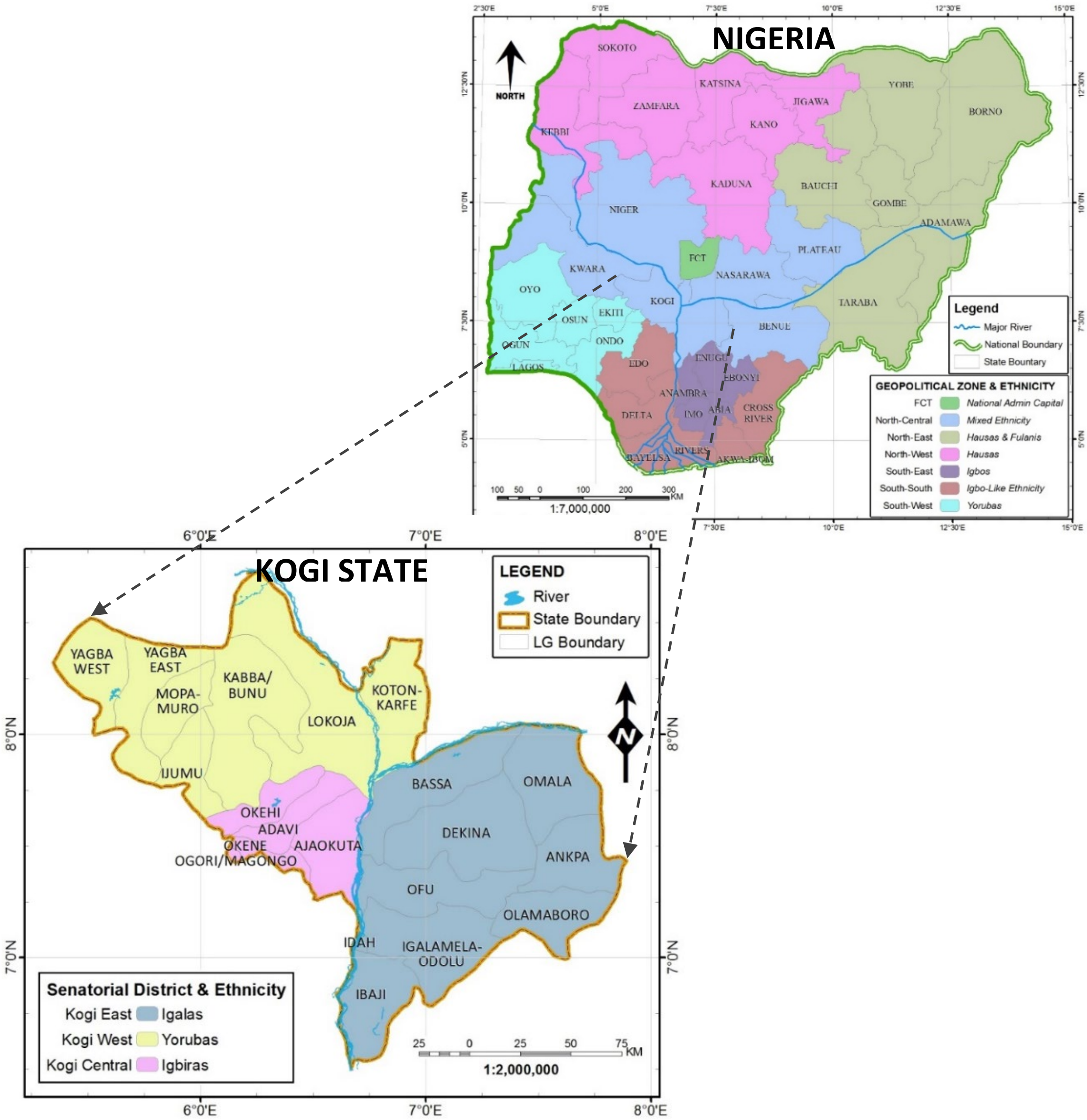

Figure 1-1 Map of Nigeria (Top RHS) showing an inset of Kogi State (Bottom LHS)

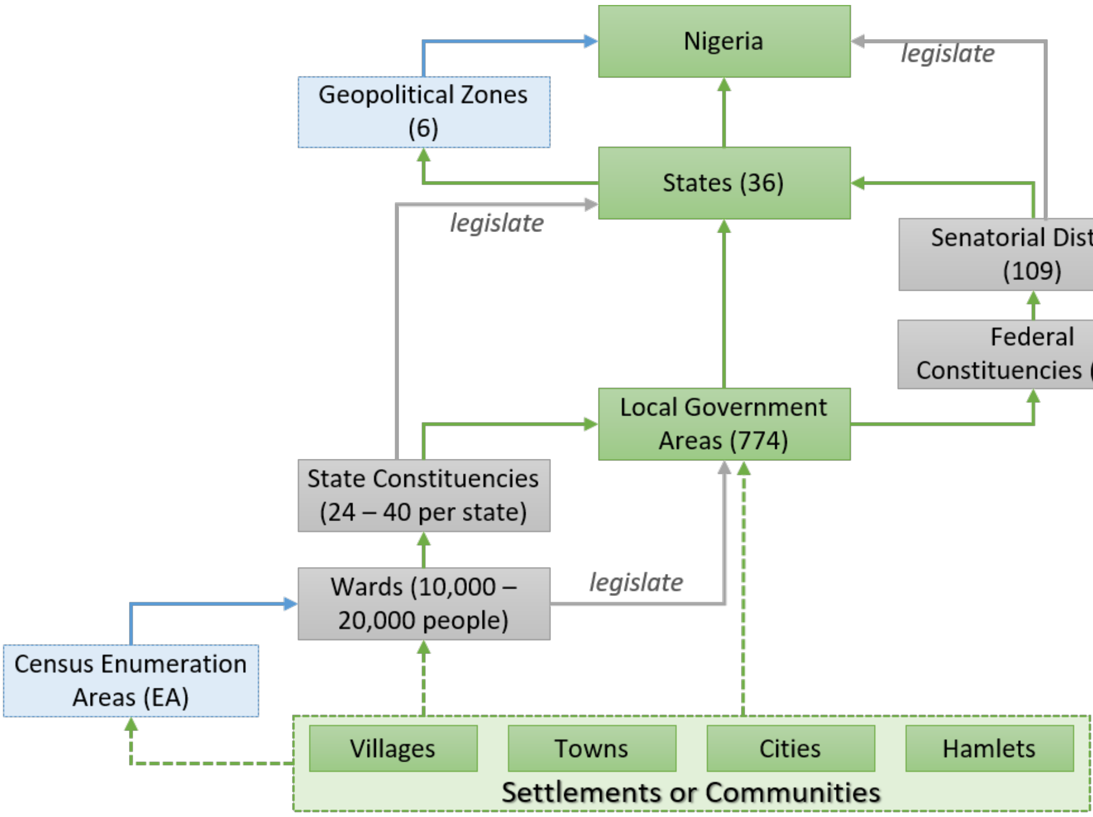

Figure 1-2 Various zoning systems of Nigeria showing statistical, legislative, political or administrative zones (Author, 2020)

Kogi State, which is the specific study area for the current project, is in the North Central Geopolitical zone of Nigeria. It is almost centrally located in Nigeria, at the confluence of Rivers Niger and Benue, between latitude 6° 30"N – 8° 45"N and Longitude 5° 20"E – 7° 55"E. It covers a land surface area of about 29,044 km^2. This is illustrated in Figure 1-1 which also shows how Kogi State is a microcosm of Nigeria, as discussed further below. The state has three senatorial districts and 21 local government areas, as shown in the inset of Figure 1-1 (and Figure 6-1). The three (3) major ethnic groups in the state are: Igala, Ebira and Okun, each of which is dominant in a senatorial district. Other minor ethnic groups include: Bassa, Kakanda, Kupa and Ganagana. Aside from this ethnic diversity, the state is heterogeneous in various other aspects, such as socioeconomics, languages, settlement types and density, as well as religion. The plurality and complexity of the state are evident and have been a matter of continuous discourse and analyses, especially by interested academics and public policy analysts in Nigeria (see for example Omotola (2008)).

Though situated within Nigeria, Kogi State bears several striking similarities with the whole country. This qualifies the study area to be described as a microcosm of the larger entity. For instance, whilst Nigeria comprises six (6) geopolitical zones with distinct ethno-religious composition, a similar pattern is exhibited by Kogi State. The three (3) senatorial districts of Kogi State have distinctive ethno-cultural patterns, which form the basic unit of qualitative analysis in this study as discussed further in Section 3.4.1. It is therefore not surprising that Omotola (2008) aptly describes Kogi State as "quintessentially Nigeria" in terms of its geodemographic characteristics, in addition to underscoring the intricate intra-state struggles for fairness, equity, and justice especially by ethnic minorities. Hence, in this study, Kogi State is construed as a miniature Nigeria, a microcosm that serves as a suitable case study focus of Nigeria. The next section considers the national healthcare system and policies, while further discussions of the study area context are featured in Section 3.4.1 in light of the qualitative primary fieldwork conducted.

1.5.2 The Healthcare System and Policy of Nigeria

The development and evolution of healthcare services in Nigeria is well-documented, including details of the current health system and policies of the country (Scott-Emuakpor, 2010; Awaisu *et al.*, 2016; FMoH, 2016, 2018; Nnadi, 2020). Thus, this section provides a summary with a focus on aspects that are relevant to primary healthcare access, especially spatial accessibility, which is the theme of the current research project.

Nigeria operates a pluralistic healthcare system with both public and private sectors as well as modern and traditional systems providing healthcare at the same time. The three tiers of government (depicted in Figure 1-2), all of which exercise substantial autonomy and authority in the utilization and allocation of their resources/funds, are concurrently responsible for the provision of public sector healthcare, as illustrated in Figure 1-3. Thus, Nigeria has a three-tier health system in which – LGAs are responsible for PHC services, state governments provide secondary level care while the federal government provides tertiary level care. In addition to tertiary healthcare provision, the FMoH leads the development and implementation of specific public health programmes, such as National AIDS and STDs Control Programme (NASCP), National Malaria Elimination Programme (NMEP), National Tuberculosis and Leprosy Control Programme (NTLCP). The Federal and State Health Ministries, Departments and Agencies (MDAs) manage the implementation of these programmes at all levels. Although roles and responsibilities are ascribed to each level by the National Health Act (2014) and National Health Policy (2016) (Federal Republic of Nigeria, 2014; FMoH, 2016), there remain some confusion with consequent problems in the administration of the country’s primary healthcare system (Uzochukwu, 2017, p. 7).

Despite the proliferation of public healthcare agencies, Nigeria has a burgeoning private health sector which accounts for 60% of national healthcare provision through its 30% share of healthcare facilities in the country (FMoH, 2018, p. 7). This includes not-for-profit services provided by faith-based and non-governmental organizations; and private-for-profit providers. The broader private health sector also includes traditional medicine providers, patent and proprietary medicine vendors (PPMVs), drug shops and complementary and alternative medical practitioners.

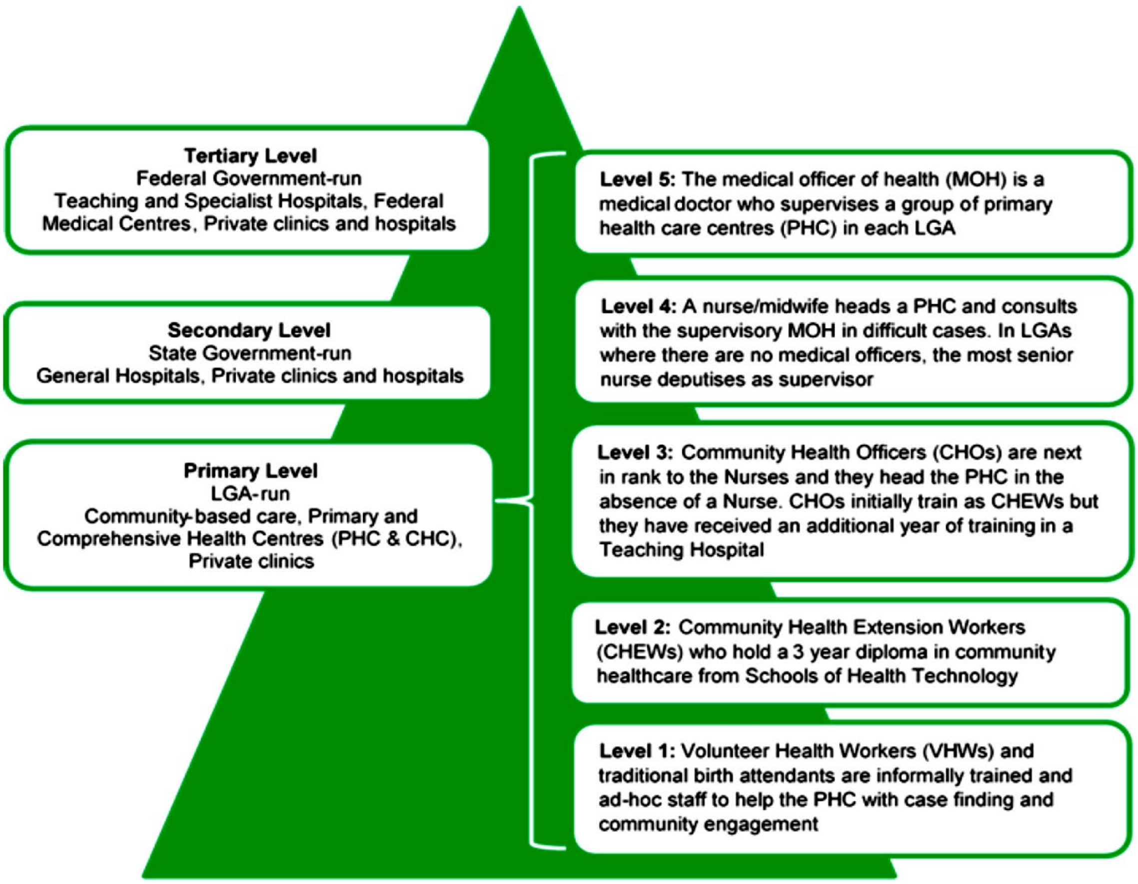

Figure 1-3 Nigeria’s healthcare system (Federal Ministry of Health (FMoH), 2018, p. 6)

The primary document which outlines Nigeria’s long-term health development plan for the period 2016 - 2030 is the National Health Policy (NHP) of 2016 whose mission is to achieve the UHC agenda in consonance with the third SDG (FMoH, 2016, p. 17). To this end, the overarching goal of the NHP is “to strengthen Nigeria's health system, particularly the primary health care sub-system, to deliver quality, effective, efficient, equitable, accessible, affordable, acceptable and comprehensive healthcare services to all Nigerians”. Not only is this grounded in the principles of social justice and the human right to health, but it also underscores the responsibility of the government in ensuring the health of Nigerians using the primary healthcare approach. For instance, it recognizes that equity in the access and use of healthcare services are social values which require that all health interventions focus on poor and vulnerable population subgroups, among other things. In terms of health service delivery, the goal is to "provide and ensure access to, and use of, high quality and equitable healthcare services, especially at the primary healthcare level, by all Nigerians" (*ibid*, p. 27). This includes the provision of a minimum healthcare service package, the enhancement of demand-creation through responsiveness to population healthcare needs, as well as improvement in the quality of healthcare services. The availability and distribution of functional healthcare facilities of appropriate quality will also be improved in order to ensure equitable access to health services, especially in underserved areas (*ibid*, p. 32). Equitable distribution and access to healthcare services will be promoted through the Ward Health System. Furthermore, there should be at least one fully functional primary healthcare centre and secondary hospital per ward and LGA respectively, all of which should have appropriate and adequate human resources for healthcare provision (*ibid*, p. 29).

The NHP is being operationalized and implemented through three cycles of National Strategic Health Development Plans (NSHDP) of 5 years period each, the second being the current NSHDP II for 2018 to 2022 (FMoH, 2018). With 15 ambitious goals, some of the NSHDP goals directly connected with the current research project are (*ibid*, p. 47):

- Promote universal access to comprehensive quality sexual and reproductive health services throughout the life cycle and reduce maternal, neonatal, child and adolescent morbidity and mortality in Nigeria (Goal 4);
- To have in place the right number and skill mix of competent, motivated, productive and equitably distributed health workforce for optimal and quality healthcare services provision (Goal 9);
- To improve the availability and functionality of health infrastructure required to optimize service delivery at all levels and ensure equitable access to effective and responsive health services throughout the country (Goal 10).

With regards to health infrastructure needed for optimal healthcare delivery, the target of the NPHDP II is to ensure that 50% of LGAs have functional general hospitals; and 80% of all health facilities have fully functional infrastructure needed for supporting service delivery (such as medical equipment, water, electricity, roads, waste disposal, security and ICT). In terms of medical emergencies like road traffic accidents, the target is to ensure that 50% of patients can obtain care within one (1) hour of an incident, in accordance with the golden hour rule (*ibid*, p. 96).

Consonant with the current NSHDP II (2018), the Ward Health System (WHS) (2018) is “the current national strategic thrust for delivery of quality PHC services in Nigeria for improved health outcomes and is the model of implementation for achieving Universal Health Coverage (UHC)” (NPHCDA, 2018c, p. iii). The goal is to improve and ensure access to sustainable, quality, acceptable and affordable health services with the full participation of people at the community level and thereby achieve Universal Health Coverage (UHC). The WHS initiative was introduced in 2001 following the recommendations of a WHO Review Team in 1992, which noted that "community mobilization would greatly be assisted if the boundaries of the then health district are the same as the electoral ward (20,000 to 30,000 people) which elects a councillor to the LGA" (NPHCDA, 2018c, p. 1; 2018b, p. 29). At the time of the recommendation, the LGA was considered the functional unit, the ‘platform’, for PHC provision in the country; since there was no clear/standard demarcation of ‘district’. LGAs had been carving for themselves what they perceived as districts, which apparently was not uniform as well as being susceptible to haphazard modifications with time, probably in response to changing political administrations. Thus, the rationale of the WHO Review Team (of 1992) was that political wards provide nationally acceptable targeted areas of operation with clearly defined boundaries, political representation and population. They contended that WHS is more sustainable than the previous health districts because it would facilitate capacity building of communities and harness grassroot political participation towards owning the health system. Consequently, a three-tiered multilevel administrative-cum-geographical structure (of Community/Villages nested in a Ward nested in a LGA) replaced the previous two-tiered structure (of Districts/Villages nested in LGA) in the provision of PHC services in the country.

The lack of standard and consistent (or mappable) health districts as at 1992 as well as the relatively large spatial size of LGAs were the main motivations of the WHO Review Team (of 1992) for recommending the WHS, which led to the adoption of political wards as the platform for PHC planning and delivery in the country by the year 2000 (NPHCDA, 2018b, p. 29). Being mainly referenced as gazetteers identifiable by their political names and their inherent villages/communities, the political wards in Nigeria are yet to be officially mapped (as at year 2018). Furthermore, the current WHS (2018) recognizes three (3) PHC facility types, namely:

1. **Health Post**: to cover a population of 500 to 2,000 persons in a settlement or village.
2. **Primary Health Clinic**: to cover a population of 5,000 to 10,000 in a group of settlements/neighbourhood, villages (village areas) or communities.
3. **Primary Health Centre**: to cover a population of 10,000 to 30,000 in a political ward.

However, the geographical region to be served by Health Posts and Primary Health Clinics remains both vague and susceptible to many of the problems with the pre-2000 health districts, since there are currently no standard mappable demarcations for these regions. Thus, even though aligning the current WHS with extant political wards may be considered expedient for governance and participatory reasons, it tends to be inconsistent with both the country's aspirations for enhanced and equitable PHC accessibility as well as the outlined NHP values of social justice which prioritizes disadvantaged, vulnerable and underserved population groups. The implausibility of these aspects of the health policy is now becoming apparent following the country's aspirations to produce health maps for LGAs with a view to facilitating appropriate strategies for service delivery (NPHCDA, 2018b, p. 9). For instance, in implementing the primary healthcare plan for LGAs, the PHC guideline (NPHCDA, 2018b, p. 13) explains that "although it might be expedient to adopt existing boundaries, in some places such ward boundaries might be too large, either geographically or in terms of population… Ideally, it is advisable that each PHC health district/ward be comprised of one or two political wards for ease of identification and management." This suggests that there is a dire problem of locality planning in the country, which also exerts a strong deleterious effect on PHC accessibility (Bullen *et al.*, 1996; Coombes, 2000; Shortt *et al.*, 2005). Despite this realization, the policy thrust of the current administration in Nigeria remains "one functional PHC centre per ward", based on the premise that this will ensure increased healthcare access for the entire population since about 80% of health conditions affecting Nigerians can be readily managed at the primary healthcare level (NPHCDA, 2018c, p. 15).

From the current NHP and NSHDP II, it can be inferred that the current plans for enhancing accessibility to PHC services are antithetical to the principles of social justice and equitable access which the same policy documents claim to promote. For instance, it aspires to ensure the presence of equally sized PHC and secondary hospitals per Ward and LGA, respectively, regardless of the need population of these zones. This proposed constellation of PHC facilities is likely to be suboptimal (and therefore create some redundancy and inefficient use of scarce resources) since regardless of the size and population of extant zones (i.e. wards and LGAs), one healthcare facility would be sited. Even though these NHP states that priority attention will be paid to poor and vulnerable subgroups, as well as underserved areas, it is not clear how this targeting will be achieved. For instance, the plan is to distribute an equal quantity of healthcare services and healthcare personnel in every geographical context, even though urban areas are known to have a preponderance of private healthcare providers. The implication is that inequalities in accessibility will be reinforced by the current policy since urban areas naturally have the advantage of being attractive to private healthcare providers. There is also dissonance in the access indicators referenced in the same documents. For example, while most indicators are based on the percentage of zones (i.e. Ward or LGA) which have a facility with the requisite primary healthcare service, in the case of an emergency road accident, the 'golden hour' rule becomes the benchmark. This begs the question, to what extent would the distribution of PHC facilities based on the WHS ensure that road accident victims can obtain healthcare within one-hour travel time – the golden hour rule? In the final accessibility analysis of Nigeria's current national healthcare policies and plans, the WHS founded on extant political wards is considered to be fundamentally problematic for assuring improved and equitable accessibility to primary healthcare services in Nigeria (Bullen *et al.*, 1996). This is discussed further in Section 3.3.1, with relevant empirical analysis performed in Chapter 4. Following this, there is a return to relevant evidence-based policy-relevant recommendations in Section 8.2.2. The remainder of this chapter briefly delimits the scope of this doctoral research, after which the structure and content of the remaining chapters of this thesis are outlined.

1.6 Research Scope and Thesis Structure

This research project is mainly concerned with theoretical and empirical aspects of the need and accessibility of PHC services in Nigeria, including both objective and subjective facets. However, objective dimensions are prioritized, thereby privileging quantitative methods, particularly spatial analytics. Nevertheless, it is acknowledged that subjective aspects are equally relevant, especially for understanding humanistic and cultural mediators of this research agenda (Johnston and Sidaway, 2016c). Kogi state, which is a microcosm of Nigeria, is the case study for the analysis in this project. The foregoing succinctly delimits the scope of this doctoral thesis, while the remainder of this section explains its structure.

Chapter 2: Theoretical Framework and Literature Review

Chapter 2 begins by explicating the ethical and moral foundations of healthcare need and access, to further foreground the salience of this research project. This warrants succinct discussions of: distributive justice with a focus on the egalitarian theory of social justice, human rights to health(care) and the health-related Sustainable Development Goal (SDG). These underscore a necessity for the welfarist approach of this study, which is both context- and culturally-sensitive, averse to inequity and attuned to the needs and perspectives of the research population. In this way, the socio-spatial focus of this thesis is on vulnerable, marginalized and underserved population subgroups, as exemplified in Chapter 7 (Gesler and Kearns, 2002, p. 159; Rosenberg, 2014, 2016). Following this is a return to the traditional focus of geographical studies on healthcare accessibility, namely: concepts, methods and applications (van Wee, 2016). This chapter explores and critically explicates theoretical and conceptual literature relevant to healthcare needs and access, in which relevant debates and controversies are identified and clarified. Through a discussion of contemporary concerns of healthcare accessibility in health and development geography, some of the knowledge gaps addressed in this thesis are underlined. In so doing, I explain that a cardinal motivation for geographical studies of healthcare access, such as the current thesis, is advancing the frontiers of knowledge in terms of methodological and application innovativeness and sophistication with a view to informing evidence-based policies and practice (Smallman-Raynor and Phillips, 1999, p. 425; Rosenberg, 2016).

Chapter 3: Research Methodology: A Spatial Mixed Methods Research (SMMR)

Chapter 3 corroborates Chapter 2 by providing a critical exploration of methodologies for accomplishing the objectives of this research project, thereby enabling the identification and adaptation of relevant methods for the empirical chapters. In so doing, limitations and critiques of the various methods are also underlined. In this way, the specific methods employed in this thesis are explained and rationalized. Automated zone design is used to accomplish the first research objective; spatial microsimulation modelling is utilized for the second objective; generalized two-step floating catchment area analysis is used for computing spatial accessibility indices in meeting the third objective; framework analysis is the qualitative analysis used for meeting the fourth objective (Green and Thorogood, 2004a, p. 184). All of these methods are synergized in an explanatory sequential mixed methods research design, which embodies a corpus of sophisticated spatial analytics as explained further in chapter 3.

Relevant data types and sources are also discussed, as necessary preludes to subsequent empirical chapters.

Chapter 4: Developing Optimized Small-Area Analytical Zones: Automated Zone Designs in LMICs

Chapter 4 actualizes the first objective of this doctoral research project. According to the National Primary Healthcare Development Agency (NPHDA) of Nigeria, a Primary Healthcare (PHC) facility should be sited in every ward (NPHCDA, 2012). Although this is an inefficient plan, it implies that the optimum spatial scale for analyzing accessibility of PHC in Nigeria is the ward zoning system, expected to have a population of between 10,000 to 20,000 people. Since there is a lack of mappable ward geographies and other small-area geographies/zones in Nigeria (as of 2018), this necessitates the development of a synthetic ward zoning system optimized for the analytical purpose of the current project. With this comes further benefits, such as the possibility to address well-known extraneous spatial effects of data aggregation, such as the MAUP, ecological fallacy, aggregation-induced errors and small population problem, amongst others (Cromley and McLafferty, 2012, p. 362; Bell *et al.*, 2013; Gautam *et al.*, 2014, p. 12; Chen, 2019). This also informs a problematization of the extant zoning system in the country, which tends to embody gerrymandering with attendant consequences on socio-spatial inequities in healthcare access. Chapter 4 therefore sets forth specific details on the design and automated creation of optimized analytical small-area zoning system. This serves as a veritable foundation for all other spatial analytics in the current study (Cockings *et al.*, 2013).

Chapter 5: Small-Area Estimation of Standard Multivariate Health-Related SDG Indicators: Spatial Microsimulation Modelling (SMM)

To accomplish the second objective of this thesis, Chapter 5 discusses the estimation of standard (i.e. SDG-related) small-area indicators of the need and potential demand for primary healthcare services in the study area. Here, the focus is on small-area estimation of standard indicators of HIV/AIDS and sexual behaviour as well as the number of sexually active people. Not only are these some of the serious SDG-related healthcare challenges in Nigeria, but they are also nontrivial indicators of healthcare need to estimate for small-areas (Cuadros *et al.*, 2017). This warrants an innovative implementation of Spatial Microsimulation Modelling (SMM) in this chapter. This approach is also applicable for small-area estimation of all other multivariate SDG-related indicators using relevant sample survey microdata. Extant health-related SDG indicators are not available at fine spatial scales, being available only at national and sub-national scales, which are often too coarse for efficient and precise spatial planning and targeting of local healthcare policies and interventions (Leyk *et al.*, 2013; Wollum *et al.*, 2015; AbouZahr *et al.*, 2017, p. 12; Rahman and Wazed, 2018). The challenge therefore is the disaggregation of these standard health-related indicators to the small-area spatial scale that is appropriate for the current study (i.e. the optimized synthetic ward zones derived from Chapter 4). In the process, the innovative development of the spatially-enriched synthetic population in this chapter also speaks to a need for spatial modelling operations to more effectively incorporate a study population at micro-level scales (Foley *et al.*, 2009). Among other things, this facilitates better accounting and understanding of contextual/ecological factors that may mediate HIV/AIDS and sexual behaviour (as well as other developmental) indicators in very heterogenous LMICs like Nigeria (Benefo, 2010; Uchudi *et al.*, 2012).

Chapter 6: Spatial Accessibility of Primary Healthcare Services: Generalized Two-Step Floating Catchment Area (G2SFCA) Analysis.

Chapter 6 provides specific details on the analysis of spatial accessibility to a modicum of baseline healthcare services in the study area, which collectively are regarded as Primary Healthcare (PHC) Services. This meets the third objective of this doctoral thesis in which an advanced method of analyzing spatial accessibility, the Generalized Two-Step Floating Catchment Area (G2SFCA) analysis is implemented with a view to revealing small-area variations in spatial accessibility of PHC services in the study area as well as identifying eMUAs for subsequent qualitative analysis. Two notable improvements to the classical Two-Step Floating Catchment Area (2SFCA) analysis are featured in the G2SFCA analysis of this study: (1) a continuous Gaussian distance-decay weighting between origins and destinations is implemented at the demand-side and (2) variable catchment areas' size and shape for demand points are modelled after the spatial patterns of *n* nearest supply points. Among other things, these incorporate a more realistic representation of potential travel behaviours in the large heterogeneous study area of this project, which contains various settlement types with very disparate population patterns or density. From the resulting accessibility indices, eMUAs are identified and characterized, with the aid of various maps and charts. Variations in the accessibility of each PHC service are also depicted at multiple spatial scales using boxplots and relevant tables.

Chapter 7: Healthcare Experiences and Perspectives in eMUAs

Missing from most spatial analytics of PHC accessibility is a deep understanding of what a lack of access means in everyday life of deprived people (Rosenberg, 2016; van Wee, 2016, p. 11). The supply of proximal healthcare services does not always result in acceptance and then optimal utilization of such services, because there may be other intervening barriers to healthcare utilization in various localities. Relevant interventions therefore have to be contextually/culturally sensitive. Chapter 7 discusses experiences, perspectives, desires/preferences and potential reception of primary healthcare services in the eMUAs of the study area. This features qualitative analysis of the primary data derived from focus group discussions in the study area. Specifically, a framework qualitative analysis (Green and Thorogood, 2004a, p. 184) is used in this chapter, first to corroborate and/or validate some of the findings of the spatial analytics; second, to provide further qualitative insights relevant to primary healthcare needs and access in Kogi State, Nigeria. Furthermore, by giving participants in eMUAs a voice, this study seeks both to emancipate them and act as an advocate (Gesler and Kearns, 2002, p. 159; CSDH, 2008). The presentation and discussion of findings from the qualitative data analysis form the content of this chapter.

Chapter 8: Summary and Conclusion

In this chapter, the key findings of this study are summarized, organized according to the research objectives. In concluding, the main implications of this study for researchers and policy makers are outlined. It is crucial to move beyond nationwide (or large-area) indicators of development, which mainly serve the interest of international organizations and donor agencies, to small-area development indicators which are very useful for policy making, local-level planning and intervention targeting (Wollum *et al.*, 2015; Rahman and Wazed, 2018). Not only do national-level indicators of sustainable development mask pockets of extreme disadvantage within LMICS, by so doing, they also reinforce extant inequalities in these contexts – an undesirable outcome (UNDP Nigeria, 2016, p. 61; AbouZahr *et al.*, 2017, p. 12). In a similar vein, there is a need to disentangle health districts from political districts in Nigeria, so that inequities embodied by political districts are not inherited by potential healthcare interventions. In eMUAs, social exclusionary mechanisms act both to create and perpetuate access-related disincentives and, at the same time, undermine proximal interventions for mitigating these difficulties. Thus, it is necessary to enact holistic interventions that are able to counteract relevant aspects of social exclusion in the study area, since previous efforts at addressing only concerns of healthcare accessibility have proven unsuccessful (Eslava-Schmalbach *et al.*, 2019). Limitations of this research project, as well as directions for further studies, are also discussed in Chapter 8.

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Chapter 2. Literature Review and Theoretical Framework

2.1 Introduction

As explained in Chapter 1, the overall goal of this study is to comprehensively analyze small-area need and accessibility of primary healthcare services in Nigeria, with a view to discursively exploring people's experiences and perspectives in extreme Medically Underserved Areas (eMUAs). Put differently, primary healthcare needs and accessibility are modelled as realistically as possible with a view to revealing and explaining observed socio-spatial variations in the study area. Among other things, this is intended to inform context-specific evidence-based policy making, pursuant to the Universal Health Coverage (UHC) agenda of the Sustainable Development Goals (SDGs). This research agenda also attempts to overcome typical downsides of positivist inclinations of traditional analysis of spatial accessibility operationalized with GIS, such as the disregard for: human experience and participation, social power, and other non-measurable properties of people and places (Pickles, 1995; Cope and Elwood, 2009, pp. 16,25; Aitken and Kwan, 2010; Johnston and Sidaway, 2016b, p. 159). Consequently, even though the traditional focus of research projects on healthcare accessibility is on concepts, methods and applications (van Wee, 2016), the current research is pertinent to a broad spectrum of health geographers and other related research audiences. Speaking from a qualitative research inclination, Gesler and Kearns (2002, p. 159) note that:

> The health geographer is theoretically knowledgeable, up to date on the social and cultural debates that inform her or his work. At the same time, he or she is interested in the practical results of research; one is an activist, an advocate for the marginalized and underserved. Health geography studies should combine methodological rigour with sympathy for the researched, often a fine line to tread. Finally, the health geographer is alert to aspects of health care delivery that one ordinarily misses, such as people's feelings and experiences, concrete and abstract symbols in the landscape, human diversity, inclusion and exclusion, and the stories that people tell.

To this end, this chapter situates the current research in relevant bodies of literature. Relevant theories, concepts, debates and themes are explored and critiqued. Gaps and downsides of the existing literature are also identified, with explanations of how they are filled or overcome in this study.

Theories are used in different ways for quantitative and qualitative research; therefore, the choice and use of theories in Mixed Methods Research (MMR) designs is a complicated matter (Creswell and Clark, 2018b, p. 153), more so that this study considers spatial dimensions. It is therefore not surprising that empirical health-related studies employing MMR designs seldom specify a particular conceptual framework (Evans *et al.*, 2011). To resolve this complexity, various relevant social and spatial science theories and conceptual frameworks are weaved into this literature review chapter, in pursuit of the values (i.e. axiology) and objectives of this thesis (NIH Office of Behavioral and Social Sciences Research, 2018, p. 8). This research project favours an emancipatory perspective that supports marginalized, underrepresented or disadvantaged groups by advocating for social justice, human rights and optimal resource redistribution/allocation in order to improve their welfare (i.e. population health). This is also in tandem with the Sustainable Development Goal (SDG) aspirations discussed in Section 2.2.3. Therefore, this study both acknowledges and endorses contemporary concerns of health geographers as informed by the 'cultural turn' in social sciences (Gesler and Kearns, 2002; Parr, 2003; Dorn *et al.*, 2010; Johnston and Sidaway, 2016a, p. 245). These ideas are therefore infused into this research project; hence, the need for a spatial mixed methods approach, as discussed further in Chapter 3.

The structure of this chapter is outlined as follows. Section 2.2 addresses the moral and ethical perspectives of healthcare access, while Section 2.3 expounds relevant concepts and frameworks of healthcare access in light of the current thesis. Many of these concepts are contentious and vaguely defined in the existing literature; hence, the same section not only disambiguates but also outlines their operational meaning for this study. In doing this, relevant conceptual frameworks are invoked with a view to establishing the theoretical framework of this study. The gaps and limitations of existing studies are expounded in Section 2.4 (and Chapter 3), while simultaneously situating this study in various interrelated bodies of literature. These also inform this study's robust Spatial Mixed Methods Research (SMMR) design, which is discussed in Section 3.1, representing an advance upon existing research designs on this research theme. A summary of the main arguments of this chapter is in Section 2.5.

2.2 Moral and Ethical Foundations of Healthcare Access

The theoretical foundations of UHC are discussed in this section, from an ethical/philosophical perspective. This serves as a necessary backdrop for understanding the motivations and axiology of the current study.

2.2.1 Health, Healthcare and Fundamental Human Rights

A human rights approach (to healthcare and health outcomes) 'seeks to describe – and then to promote and protect – the societal-level prerequisites for human well-being in which each individual can achieve his or her full potential' (Mann *et al.*, 1999, p. 2). This approach comprises legal and moral (or ethical) components (Denier, 2007a). The moral component of human rights represents the desired ideals of governments and people, some of which are expected to be progressively realized[1], while the legal component is the actual domestic legislation and international agreements that are recognized and protected by the instruments of national governments. It can be argued that the legal component derives from the moral component of human rights, such that a robust perspective of the human rights approach to health(care) is offered by the moral (or ethical) component, which is the favoured perspective of this research project. This is apparent because human rights (especially the legal component) can be considered a subset of theories of distributive justice since some of these theories (such as Rawls') also consider the distribution of rights (Daniels, 2007; Rawls, 2009). The moral component of human rights is therefore both akin to and implicit in principles of distributive justice discussed in the next Section 2.2.2 below.

[1] This is the principle of 'progressive realization' which is fundamental to meeting human rights especially in resource-poor countries like Nigeria, where governments are incapable of the immediate and complete fulfilment of all positive rights. The progressive realization of a right implies that steady progress is made towards the realization of the target goal (ICESCR Article 2.1; Alston and Quinn 1987, Braveman and Gruskin, 2003). This is particularly so for the positive right to health that requires more than just passing a law, but financial resources, facilities, personnel, and sustainable infrastructure. Public (and private rights) can further be categorized as positive or negative rights. "Positive obligations require government to take certain actions, while negative ones require it to refrain from other actions such as obstructing enjoyment of the right to health" (Asher 2010, p. 24). Further explanations of positive and negative rights as well as block and one-on-one (i.e. individual) rights in the context of healthcare equity are provided by Macnaughton (2011). Relatively modest investments are required for the actualization of negative rights protecting individual's political freedoms. However, because of differences in the economic resources of countries, positive (public) rights which are often dependent on social welfare are more difficult to actualize internationally. Positive rights comprise both an individual and a collective dimension. In the current research project, it is sufficient to state that positive rights raise much more difficulties in public policy formulation and social prioritization than is the case with negative rights (Newdick and Derett, 2006). In sum, the pursuit of accessibility and equities in healthcare of which this thesis is concerned has more to do with bloc positive rights.

From the legal perspective of the human rights approach, the constitution of the World Health Organization (WHO) posits that it is a fundamental human right for everyone to enjoy the highest attainable standard of health and that governments are responsible for ensuring this by providing citizens with adequate healthcare and relevant social measures (WHO, 1946, 1995). This position is reiterated by the Alma-Ata declaration of 1978 (WHO/UNICEF, 1978), which further identifies access to healthcare as a fundamental human right as well as urges countries to ensure the equitable coverage of essential healthcare by using the PHC model as a way to achieve the 'Health for all' goal of the WHO (WHO, 1998a; Pappas and Moss, 2001). Building on the foregoing premises, the world health declaration of 1998 directs countries to strive towards the goals of health promotion by voluntarily addressing the basic determinants and prerequisites of health, paying the greatest and priority attention to those most in need, burdened by ill health, affected by poverty or receiving inadequate healthcare services (WHO, 1998b; Da Costa Leite Borges, 2016b, p. 153; Eslava-Schmalbach *et al.*, 2019). Therefore, this is an invitation to social justice in health(care) through the prioritization of the health concerns of socially excluded groups. This is also the basis for the notion of 'proportionate universalism' (Marmot *et al.*, 2010; Carey and Crammond, 2017) discussed further in Section 2.3.3. This is in recognition of the fact that many of the factors that affect health, and in turn, determine healthcare needs, are unrelated to direct health interventions (Willis, 1996). These determinants of health are well documented (Dahlgren and Whitehead, 1991), and discussed further in Section 2.3.1.

An elaborate discussion of rights to health and healthcare is beyond the scope of this thesis; these are provided by relevant experts (Bole and Bondeson, 1991; Denier, 2007a; Chapman *et al.*, 2017; Dittrich *et al.*, 2017). However, suffice it to say that the current study acknowledges and endorses a fundamental human right to basic healthcare services, based on well-established specifications (Buchanan, 1997; Denier, 2007a). First, one of the key obligations of governments is to ensure that everyone has access to a decent level of healthcare services; therefore, healthcare access is a collective moral obligation. Although governments are not obliged to provide citizens with every possible healthcare service for free. Rather it is a commitment to ensuring universal accessibility (devoid of out-of-pocket payments) to a limited modicum of essential healthcare services that are contextually considered to be crucial for the attainment and maintenance of the population health (Hessler and Buchanan, 2002; Asher, 2010). This obligation is expected to be fulfilled through PHC facilities, which ought to deliver a modicum of healthcare services dubbed: Essential Health Package (EHP), as discussed further in Section 2.3.1. Second, this collective moral obligation is powerful because its conception as a fundamental human right gives it an exceptional moral force in public debate. According to Dworkin (2013), a right supersedes countervailing considerations so that important human interests are powerfully protected once designated as a fundamental right. Third, because healthcare is an established basic right, access to healthcare is owed to everyone that has the right. It follows that an injustice is done to right-holders that lack access to healthcare if governments fail to fulfil this collective obligation. Anyone that holds a right to healthcare is not kindly asking for a favour. Fourth, because it is a human right, all individuals are ascribed this right just because they are humans. However, this healthcare right is jurisdictionally-dependent (Cornelissen, 1996; Da Costa Leite Borges, 2016a); hence it is often held by citizens (and legal immigrants and other recognized persons) of countries or territories that not only are signatories to relevant international human right treaties and conventions but have localized these policies in their national constitutions, such as the study area, Nigeria.

Subtle human rights issues may arise from health programmes that are not appropriately tailored to meet the needs of marginalized groups or that fail to provide services to certain populations (Alex, 1998; Altman, 1998; Beyrer, 1998; Helga, 1998; Jackson, 1998). Human rights issues may also interact with the development of health policies and programmes when the prioritization of certain health issues is based more on existing discrimination against certain population groups than on actual needs (Gilmore, 1996). For example, paying systematically higher priority (in resource allocation, research, policy and programme) to minor health issues that predominantly impact the dominant group than more major health problems. That human right documents prohibit discrimination does not mean that differences should be ignored, but rather that reasonable and objective criteria should be the basis for differential treatments[2] (Cook, 1993; Coliver, 1995). A fundamental human right to primary healthcare access therefore implies that medically underserved areas and places (MUA/Ps) suffer a form of injustice; thus, hybrid remedial interventions should be in place, which proportionately targets and prioritizes these MUA/P as discussed further in Section 2.3.3 (Carey, 2014; Carey *et al.*, 2015b; Rahman and Wazed, 2018; Eslava-Schmalbach *et al.*,

[2] This is consistent with the tenets of equity as well as the principle of 'Proportionate Universalism' (Marmot *et al.*, 2010) discussed in Section 2.3.3.

2019). Human rights to healthcare are connected with matters of distributive justice (Hessler and Buchanan, 2002, p. 84), considered in the next section.

2.2.2 Distributive Justice in Healthcare

Having explained the significance of health(care) and explicated its special status amongst the social goods (in Chapter 1), it follows that Primary Healthcare (PHC) services should be equitably distributed. However, the rationales for (socio-spatially) distributing PHC services should be different from the distribution of the other social goods, and this should be well considered in relevant studies such as the current one. For this reason, it is necessary to turn to theories of distributive justice in health and healthcare since they tell us the type of goods that are of concern to justice and how the tenets of justice may underscore their distribution (Hurley, 2007). The effects of social (in)justice on population health are well-documented (Donohoe, 2012; Levy, 2019). Recall also that aspirations for equity in the accessibility of PHC services (as enshrined in the SDG 3) are also linked to human rights (Braveman and Gruskin, 2003b; Newdick and Derrett, 2006; Da Costa Leite Borges, 2016a), as discussed in Section 2.2.1 and Section 2.3.3.

Although this is not always mentioned, most geographical studies on aggregate healthcare access are grounded in egalitarian principles of distributive justice (Rosenberg, 2014). These studies are concerned with exposing the socioeconomic, demographic and locational dynamics of people who directly or indirectly suffer a lack of primary healthcare (and then poor health), as a result of the negligence or actions of relevant public authorities. Consequently, Pereira *et al.* (2017) provides an overview of the main theories of distributive justice, while the remainder of this section explores both utilitarian and egalitarian theories in varying depths. Utilitarian theories are the main ethical basis of (health) economics (Kelly *et al.*, 2015), while egalitarian theories underpin most public health and social welfare perspectives of healthcare, including the current study. Hence, utilitarian perspectives are summarized, whereas egalitarianism is explicated with a view to understanding its wide appeal in studies of primary healthcare accessibility such as the current project. Extensive explorations of theories of distributive justice are outside the scope of this thesis because they are matters of primary concern to social and political philosophers (Goodin and Pettit, 2019). Rather, the focus of this section is on egalitarian principles of distributive justice, which arguably is necessarily the most relevant to healthcare accessibility as implied by both the human rights approach discussed in Section 2.2.1 and operationalized in the SDGs and UHC agenda discussed in Section 2.2.3 (see also Hessler and Buchanan (2002, p. 84)).

2.2.2.1 Utilitarianism in Healthcare

Utilitarianism was popularized by the works of Benjamin Bentham. This theory postulates that actions that maximize aggregate utility are preferable, with utility being mainly the maximization of happiness and a reduction of suffering. In other words, a concern with the common good or greatest happiness of the greatest number of people is the overarching goal of utilitarians (Bentham, 1834). However, not only are utilitarian approaches insensitive to concerns of equity/fairness in resource distribution/allocation, but they may also promote conservative changes to resource reallocation. For instance, a Perato improvement which results from resource allocation (or distribution) that makes at least one person better off and no one worse off is a satisfactory utilitarian outcome (Pareto, 1935).

It goes without saying that utilitarianism advocates for the distribution of healthcare services and, indeed, other societal goods based mostly on economic/market principles (Crisp, 2002; Rosen, 2005; Mill *et al.*, 2015). Here, the main consideration is utility maximizations (in the sense of benefits/value per unit of financial input). Hence, quantitative measures like Cost Benefits Analysis (CBA), Cost Efficiency Analysis (CEA), Cost-Utility Analysis (CUA), Quality Adjusted Life Years (QALY), Disability Adjusted Life Years (DALY) etc are the main measures that determine utilitarian healthcare provision. The foremost rationale for healthcare allocations under the utilitarian framework is the maximization of overall social utility (in this case, health outcome) irrespective of ethical distributional considerations that bother on notions like morals, solidarity, fairness and equality (Smith, 1994). Utilitarians believe that because of conditions of decreasing marginal utility, it is necessary to distribute goods (like healthcare) equally in order to maximize the aggregate end state of the same good. However, it is controversial if improved health (being the desired utility outcome) is entirely subject to the specified economic conditions of diminishing returns, since unlike tangible goods such as money, human states/feelings like happiness and wellbeing may be increased infinitely and inexhaustively (*ibid*). Relying mainly on overall utility maximization, there is no authoritative claim on rights in the utilitarian perspectives (Beauchamp and Childress, 2001) because here, the rights to healthcare can only be justified by improved net social utility (Buchanan, 1984; Buchanan, 1997).

In Ruger (2009) are excellent discussions and critiques of several welfare economic indices and techniques premised on the utilitarian approach as used in health policy analyses, such as the QALY, DALY, CEA, CUA, and CBA. Even though researchers like Nord et al. (1999) have attempted to overcome this challenge by incorporating a distributional ethic (in the form of equity weights) into the utilitarian approaches, these efforts are still deficient based on some plausible concerns (Daniels, 1994; Rawls, 2009). These bother mainly on prioritization and weighting problems (Daniels, 1994, 2006), and other conflicts of principles highlighted by Nozick (1974). Sen (1991, 1999) identifies three other limitations with utility measures: First, focusing on achievements, they omit freedom. Second, improvements that are not reflected in the utility measure are disregarded (such as inclusivity, participation etc). Third, because of the tendency to adapt to adverse environments over time, people with limited functioning may no longer appear to be so deprived (Sen *et al.*, 1988; Leichter, 1992; Nussbaum, 1997); therefore, situations of persistent adversity and deprivation are not accurately measured by utilitarian approaches. The issue of incommensurability (Sunstein, 1994) is also controversial in utilitarian approaches of healthcare (Raz, 1988; Martha, 1990; Sunstein, 1994; Anderson, 1995; Ruger, 1998, 2006). The ability to compare different health conditions (like cardiovascular disease, depression, autism, deafness, blindness, diabetes, cystic fibrosis, and loss of limb) is doubtful because it is argued that different health values cannot be reduced to a unitary quantitative scale.

Therefore, most studies of primary healthcare, including the current thesis, are grounded in luck egalitarian principles of distributive justice, which are welfarist, context- and culturally-sensitive, averse to inequity and attuned to the needs of disadvantaged population subgroups (Peter and Evans, 2001, p. 28; Anand, 2004, p. 17; Denier, 2007a; Da Costa Leite Borges, 2016a). Consequently, unlike utilitarianism, which is exclusively quantitative, luck egalitarianism necessitates a mixed methods research approach as implemented in the current study (see Section 3.1).

2.2.2.2 (Luck) Egalitarianism in Healthcare

Equal access to (or distribution of) social goods is the material principle of justice emphasized by egalitarian theories (Holtug and Lippert-Rasmussen, 2007). That equals should to be treated equally and unequals unequally is the Aristotelian principle of equity that is the traditional and common criterion employed by egalitarians (Beauchamp and Childress, 2001). However, there is a lack of substance in this classic material principle until some specification is made of the kind of equality being considered because the relevant grounds on which people ought to be treated equally are not specified. Furthermore, even though extreme equality in the distribution of resources is desirable, it is not feasible to accomplish in reality (Da Costa Leite Borges, 2016a) because the legal, political and economic structures/organization of modern societies make it is impossible to achieve a completely equal resource distribution without breaching individual property rights. In addition, inequalities are likely to re-emerge from a theoretically equalized society because of the inherent differences in people's qualities, capabilities and wants. Therefore, contemporary egalitarians support only the sharing of certain societal goods and not every possible societal benefit (Beauchamp and Childress, 2001). Rawls' famous egalitarian theory advocates for the fair distribution of 'primary goods' as a matter of justice (Rawls, 1999). This is captured in his principle of 'equality of opportunity' and his 'difference principle' that has been expanded and extended into healthcare by other authors (Daniels, 1985, 2001, 2007; Rakowski, 1991). In his later works, Rawls also applied his own theory of justice in healthcare (Rawls, 1999).

Extreme or strong egalitarianism (Olsen, 1997) is avoided in healthcare because it would facilitate an absurd situation of providing healthy individuals with the same amount of care as those in real need of care. Consequently, to achieve a reasonable egalitarian outcome in the distribution of healthcare without creating this absurd situation or violating individual rights[3], additional rules or principles must be applied. The principle of (fair) equality of opportunity plus the 'difference principle' (Rawls, 1999; Daniels, 2007) as well as the 'equal opportunity of welfare' and 'equal access to advantage' approaches (Stanton-Ife, 1999) are helpful in this regard (Arneson, 1989; Cohen, 1989, 1993). According to the principle of fair equality of opportunity, it is important for the state to provide healthcare resources because health(care) plays a vital role in creating adequate opportunities necessary for everyone to pursue their preferred interests. The difference principle helps to redress the bias of contingency affecting equalities, by specifying that people born into less favourable positions and those with fewer native assets deserve more attention/support from the state[4] (Rawls, 1999). Contemporary ideas on (luck) egalitarianism and other theories of distributive justice in healthcare are well

[3] Egalitarianism is connected with fundamental human rights to healthcare (Hessler and Buchanan, 2002, p. 84).

[4] This is the premise for the notion of 'Proportionate Universalism' advocated for by the Marmot Review (Marmot, 2010)

elaborated by various authors (Denier, 2007a; Segall, 2009, 2013, 2016; Shelp, 2012; Fourie and Rid, 2017).

In short, the egalitarian theories of justice rely on the principle of fair equality of opportunity and the difference principle (also called the need principle) in designing a fair healthcare distribution. Deriving from the difference principle, the concept of need is crucial to the distribution of healthcare because actual healthcare needs should be positively correlated with the utilization of healthcare services (Gulliford *et al.*, 2002). Indeed, Rawls' difference principle implies that greater healthcare need deserves greater attention (Stanton-Ife, 1999). However, the concept of need has been a subject of much disagreement among health economists and other scholars, such that there is no generally accepted working definition of need (Oliver and Mossialos, 2004; Da Costa Leite Borges, 2016a). Instead, authors like Oliver and Mossialos (2004) suggest that the notion of healthcare needs should be refined by each country to assure consistency and support the enactment of relevant policies such as the development of regional healthcare formulas. In this light, it is worth acknowledging that basic need is different from want, with basic need capturing ideas of necessity and indispensability (Daniels, 2008), and should not be explained in terms of individually perceived or felt needs (Stanton-Ife, 1999). There is a return to further discussions of the concept of basic needs in Section 2.3.1.

As will be shown in later discussions of equity (in Section 2.3.3), the principle of fair equality of opportunity is akin to 'horizontal' equity while the need principle is consonant with 'vertical equity'. Egalitarian theories also recognize the special importance of basic healthcare as a social good that should be provided by states and then fairly distributed as a matter of justice. The universal health coverage goal (SDG 3) and inequality reduction goal (SDG 10) of the UN SDGs and other similar initiatives are premised on these egalitarian ideals (see Section 2.2.3). However, there remain some plausible shortcomings of egalitarianism, including concerns of inefficiency and controversies in healthcare resource allocation (rationing) and prioritization. Since there is never likely to be any consensus about rationing problems and distributive justice in healthcare (Daniels 1994), to address these controversies requires the use of fair democratic processes.

Daniels and Sabin (2002) and Daniels (2007) recommend 'fair procedures' for reasonable solutions termed 'Accountability of Reasonableness', as a means of agreeing on a fair resolution of disputes in the distribution of basic goods. Similar deliberative democratic procedures have been proposed by other authors (Leichter, 1992; Morone, 1992; Nagel, 1992; Rosenbaum, 1992; Beauchamp and Childress, 2001; Daniels and Sabin, 2002; Fleck, 2009; Gutmann and Thompson, 2009). Generally, these approaches incorporate the principles of political legitimacy, political equality, autonomy, deliberations, and explicit public processes (Da Costa Leite Borges, 2016a). However, similar with other authors (MacIntyre, 1988; Hadorn, 1991; Emanuel, 1994; Rai, 1997; Powers and Faden, 2000; Beauchamp and Childress, 2001; Gorovitz, 2001; Waymack, 2001), Ruger (2009, p. 35) notes that "deliberative democratic procedures run the risk of producing no acceptable options, and certainly no acceptable rationales or reasons, to the extent that one can assess reasonableness without substantive moral principles." Consequently, there remains persistent differences and controversies in the fair distribution of healthcare, with Daniels (1994) and Emanuel (1994) expressing scepticisms about the possibility of ever achieving any consensus on these rationing and distributive justice dilemmas.

The current study pursues both enhanced and equitable spatial accessibility of primary healthcare services in Nigeria, based on international recommendations for actualizing the UHC goal, some of which are highlighted in Section 8.2.2 (Carey *et al.*, 2015a; Rahman and Wazed, 2018; Eslava-Schmalbach *et al.*, 2019). Apparently, these prescriptions are grounded in both the fundamental human right to healthcare (discussed in Section 2.2.1) as well as the interlinked egalitarian principles of distributive justice discussed in this section. These two frameworks give salience to the Universal Health Coverage (UHC) agenda of Sustainable Development Goal (SDG) 3, especially the principle of Proportionate Universalism, discussed further in Section 2.3.3. The SDGs recognize the importance of concrete (quantitative) measures in characterizing and monitoring a development agenda. It also promotes the notion of social sustainability, which necessitates consultation with marginalized groups in relevant decision-making processes. This is consonant with the deliberative democratic procedures discussed in this section, which together with human rights concerns, inform the mixed methods research design of this study. UHC is the matter for discussion in the next section, in the context of the health-related SDG.

2.2.3 Health SDG and UHC

The ethical and moral principles (discussed in Sections 2.2.1 and 2.2.2) give the health SDG its principal force and salience (United Nations Development Programme (UNDP), 2018). Together with the same foundations, the health-related SDGs underscore the urgency of enhanced and equitable accessibility of essential healthcare services in the study area and world over. This section summarizes the inter-connections between relevant SDGs and the established moral and ethical principles. Furthermore, discussions on the links between the SDGs and health(care) are featured, with particular emphasis on the accessibility dimension of the UHC. These trio form the overarching foundational basis for the current study and the approach employed.

The SDGs (comprising 17 Goals and 169 targets) extensively improves on its predecessor, the MDGs, which feature 8 goals and 21 targets (UN, 2015). For instance, unlike the MDGs, which mainly target LMICs, the SDGs are relevant to all countries regardless of their level of development. The MDGs embody a narrow conception of development as a lack of extreme poverty, defined as an inability to meet basic needs. In addition to a concern for extreme poverty (inherited from the MDGs), the SDGs is broader and more ambitious, with a concern for social, economic and environmental sustainability. The concept of sustainability that qualifies development in the SDG era is therefore multidimensional (Seghezzo, 2009; Murphy, 2012). In sum, two key downsides of the MDGs which are greatly improved upon by the SDGs are (1) beyond the MDGs' myopic focus on economic interests, SDGs are better aligned with human rights standards and principles, especially equality, participation, non-discrimination, and transparency (WHO, 1998c; Office of the High Commissioner for Human Rights (OHCHR), 2008); (2) the scope of the MDGs is too narrow to engender the transformative requirements of 21st century sustainable development. Consequently, it failed to address the fundamental drivers of poverty and inequality, which are rooted in the power structures of the economy, society, and politics, as well as promoted by neoliberal economic models which, among other things are inattentive to human rights (Miller, 2001; Dickie *et al.*, 2015; Freistein and Mahlert, 2016; Briant Carant, 2017; Revenga and Dooley, 2019). While further rationalizations of the SDGs abound, suffice it to say that the SGDs are superior to the MDGs because of their increased concern for human rights and their aversion to inequalities, as well as their consideration of the broader (i.e. inter-sectoral) drivers of disadvantage and inequalities. Despite this, the SDGs have collectively or individually been criticized on some grounds. For instance, while its tangible, measurable and quantifiable aspects highlight the power of numbers in communicating the scientific certainty, seriousness and accountability of a development agenda, numbers are sometimes reductionist and simplistic, thereby causing some unintended consequences (Bond, 2006; Fukuda-Parr, 2014; Fukuda-Parr *et al.*, 2014). In using quantitative measures, intangible and complex aspects of sustainable development (such as inclusivity) are reduced to concrete measures, which have other unintended consequences, like adverse behavioural changes (Merry, 2011; Fukuda-Parr, 2016). Unintended consequences of quantitative measures are well-explained by Campbell's law, which states that 'the more any quantitative social indicator is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it is intended to monitor' (Campbell, 1976, 1979). The implications of, and remedies to the deleterious effects of Campbell's Law in the context of healthcare are well-discussed (Bevan and Hood, 2006; Poku, 2015). In this regard, it is sufficient to say that because the current study incorporates a mixed methods approach to healthcare accessibility (among other things), these unintended effects of quantification are mitigated.

Time-bound and measurable targets are invaluable to the realization of many sustainable development agendas. However, the use of undefined and subjective terms such as 'strengthen', 'quality', 'promote', 'substantially reduce' implies that some SDGs are immeasurable, failing therefore to provide objective measures. Some examples include SDGs 4, 6, 9, 11 and 15. These tensions between objective and subjective dimensions of sustainable development greatly necessitate the use of mixed methods research designs for evidence-based policy making, as implemented in this study and discussed further in Chapter 3. Despite a few critiques and resistance (Fukuda-Parr, 2016; Briant Carant, 2017)[5], this study supports and is grounded in the SDG framework, with a particular focus of the UHC goal, as enshrined in SDG 3, Target 8: 'achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all'. This study is particularly concerned with achieving equitable spatial accessibility to quality essential healthcare services in Nigeria.

Since the Alma-Ata declaration (WHO/UNICEF, 1978), countries have been encouraged to ensure the equitable coverage of essential healthcare by using the Primary Health Care (PHC)

[5] The Economist's leader on 28 March 2015 suggested that SDG stands for 'Stupid Development Goals' (see https://www.economist.com/leaders/2015/03/26/the-169-commandments, accessed on 11 September 2019).

model/approach as a medium of achieving the 'Health for all' goal[6] of the WHO (Pappas and Moss, 2001). By the same token, there has been a long-standing confusion/controversy between primary 'medical' care and the PHC model of service delivery, with the effect that one is sometimes interpreted to mean the other; and each having many different meanings (Andrews *et al.*, 2012). Hence, although both notions derive from the sixth principle of the Alma-Ata declaration[7], various (often controversial) interpretations of the same principle have been recorded (WHO/UNICEF, 1978). For example, PHC has been defined as – an approach (Canadian Nurses Association, 2005), a policy (WHO, 2003), a model, a system of care, a paradigm, or a philosophy (Cueto, 2005). However, regardless of the particular colouration of various definitions of PHC, there is currently some consensus on its meaning. PHC focuses on 'first-contact care' that is comprehensive, universal, affordable and equitably delivered (Hall and Taylor, 2003; Cardarelli and Chiapa, 2007; Haines *et al.*, 2007). Being neither service-specific nor population-specific nor piecemeal, a PHC approach targets the entire population in a holistic manner, by providing a modicum of essential healthcare services dubbed 'Essential Healthcare Packages' (EHP)[8], in an integrated efficient manner referred to as 'care under one roof'[9] (Crooks and Andrews, 2012, p. 8). While further elaborations of PHC abound (Andrews *et al.*, 2012; Sanders *et al.*, 2017), suffice it to say that it is well-established that Primary Healthcare (PHC) is the most efficient 'platform' (or medium or mechanism) for actualizing the UHC goal (SDG 3, Target 8), especially in LMICs like the current study area, Nigeria (WHO, 2013b; Kickbusch *et al.*, 2015). UHC via the PHC platform assures the provision of accessible and equitable care in, by and for communities/localities with a view to overcoming poor health and its disparities within and between countries. In Section 2.4.1, the notions of EHP and 'platform' are discussed further, in light of their empirical operationalization in this study.

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[6] The same 'health for all' goal of the WHO is persistent, having evolved into the contemporary UHC agenda, as enshrined in the SDG (as target 3.8)

[7] Principle VI of the Alma-Ata Declaration (WHO/UNICEF, 1979): "Primary health care is essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination. It forms an integral part both of the country's health system, of which it is the central function and main focus, and of the overall social and economic development of the community. It is the first level of contact of individuals, the family and community with the national health system bringing health care as close as possible to where people live and work, and constitutes the first element of a continuing health care process."

[8] WHO, 2008; Kapiriri, 2013; Glassman *et al.*, 2016; Chapman et al., 2017; FMoH, 2018, p. 13; Watkins *et al.*, 2018

[9] Bruggmann and Litwin, 2013; Sharma *et al.*, 2013; Rumball-Smith *et al.*, 2014

The selective and piecemeal nature of research works (as well as policies and interventions) on healthcare services aimed at actualizing the UHC agenda (as well as the overall SDGs) is a popular critique of existing studies (Walsh, 1988; Litsios, 2002; Hall and Taylor, 2003; Cueto, 2004). Among other things, the current study overcomes this downside by considering a modicum of 'baseline' healthcare services that are relevant to the study area. In endorsing Nigeria MDG Information System (NMIS) health facility data developed by the Office of the Senior Special Assistant to the President on the Millennium Development Goals (OSSAP-MDGs)[10] in partner with the Sustainable Engineering Lab at Columbia University, this study adopts the seven (7) NMIS baseline healthcare services as PHC services for the study area[11]. This approach is therefore congruent with the UHC aspirations of the SDG, as discussed further in Chapter 6. Section 2.3 clarifies the main concepts associated with healthcare access, with a view to explicating their nominal/normative and operational meanings for the current thesis (Abler *et al.*, 1971, p. 33).

2.3 Key Concepts and Frameworks of Healthcare Access

The concept of 'distance decay', which describes the general relationship between activity rates and accessibility, is famous in geography and health services literature (Haggett *et al.*, 1977). It posits that most human activities (such as the patronage for healthcare services) vary inversely with travel distance/time (Joseph and Phillips, 1984; Carr-Hill *et al.*, 1997; Barnett and Copeland, 2010). The inverse-care law (Tudor Hart, 1971, 2000) is a typical manifestation of inequalities in healthcare services with the effect that population and places with the most healthcare needs often are provided with (and/or receive) the least amount of healthcare. The Inverse-care law, reinforced by an 'inverse-equity hypothesis' (Victora *et al.*, 2000) suggests that inequities are worse in unregulated healthcare systems and in places where healthcare is entirely driven by market forces. These notions of 'inverse-care' and 'distance-decay' are influenced by multiple factors, including: the type of healthcare needs (i.e. the criticality of the ailment), the demography (in terms of age, gender, socioeconomic status etc), beliefs and behaviours, and perceived outcome (a function of the quality of services, or other factors associated with the healthcare system). These factors vary spatially and temporally,

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[10] This is now the Office of the Senior Special Assistant to the President on the Sustainable Development Goals (OSSAP-SDGs), see https://sdgs.gov.ng/

[11] See https://redivis.com/CWP/datasets/1449 or https://energydata.info/dataset/nigeria-nmis-health-facility-data-2014.

hence local variations in the spatial and demographic coverage of healthcare services need to be accounted for in planning for an effective and equitable healthcare system.

The remainder of this section explores core terminologies that are relevant to this thesis with a view to clarifying their operational meaning and relevance. Many of these concepts are contested, and therefore do not have universally agreed definitions. Following this, Section 2.4 considers current research trends and knowledge gaps with a view to further grounding this thesis in the existing body of literature.

2.3.1 Need and Demand for Healthcare Services

2.3.1.1 Need for Health and Healthcare

The concept and assessment of health(care) need are indispensable bases for adjudging the distributive justice of an intervention (Olsen, 2011). Consequently, the right to healthcare, as well as the associated principles of (egalitarian) distributive justice are premised on the concept of basic needs otherwise referred to as 'course-of life' needs (Braybrooke, 1987) or 'non-violational needs' (Frankfurt, 1988). Things that are essential to livelihood or normal functioning and are functionally necessary for the most fundamental projects of human living are referred to as basic needs (Denier, 2007a). Being basic, they are not a function of frivolous pursuits or individual whims, but rather are restricted to universally recurrent phenomena; therefore, they are differentiable from preferences, felt needs or wants. Every human being is involuntarily in need of basic needs, most of which concerns a person's physical (like drink water and shelter) and psychological existence (like affiliation, support and communication). Basic needs are considered to be intrinsic characteristics of the human condition, being that they are not acquired; hence, they are not dependent on merits. Basic needs (like primary healthcare needs) that are naturally unequal are thought of as fortuitously distributed; as a result of good or bad luck/fortune or as part of a kind of social or natural lottery (Denier, 2007a). The concept of basic needs is well explained by: the basic needs approach (Galtung, 1980; Stewart, 1996), various typologies of needs (Maslow, 1943, 1989; Murray, 1962; Bradshaw, 1972a, 1974), as well as a theory of human need (Doyal and Gough, 1991). Whereas Harrison *et al.* (2013) provide an excellent discussion and critique of the various conceptualization of basic needs, the remainder of this section focuses on basic healthcare needs and the demand thereof.

Despite the enduring controversies and debates associated with the concept of basic healthcare needs (Acheson, 1978; Culyer, 1995, 1998; Harrison *et al.*, 2013), it can be seen from the foregoing that primary/basic healthcare needs are among basic needs because they are: necessary for the fundamental projects of human existence; characteristically universal; and originate generically from human finitude and vulnerability. It follows that basic healthcare needs are things that everybody needs in order to maintain or restore normal or healthy functioning (like adequate nutrition, shelter, sanitation, hygienic living and working condition, preventive and curative medical services) or that are necessary to equal normal functioning insofar as possible (like hearing aids, eye glasses, guide dogs and wheelchairs). Some health advantages and the burdens of illness are often arbitrary effects of good or bad luck, natural lottery (like a person's genetic composition), or social conditions (like socio-economic deprivation). These are well-explained in many conceptual frameworks of (socioeconomic) determinants of population health (Dahlgren and Whitehead, 1991; Kaplan *et al.*, 2000; Institute of Medicine (IOM), 2003; Etches *et al.*, 2006), one of which is illustrated in Figure 2-1. These determinants are well-explained by relevant authors (Krieger, 2011; Hosseini Shokouh *et al.*, 2017). Despite interpersonal differences in healthcare needs, it is of fundamental value for everyone to enjoy reasonably good health in order to function normally and thereby have normal opportunities to lead a fulfilling life. Therefore, every country that is just has a basic moral obligation to eliminate or reduce conditions that undermine good health.

There are several reasons why it is implausible to expect that everyone would be able to meet their basic healthcare needs relying exclusively on their own private resources (Denier, 2007a). Unlike other basic needs like food, shelter and clothing, healthcare needs are very unequally distributed, so that some people need significantly more healthcare than others do. For instance, considering a basic need like nutrition, all adult humans have a recommended daily average energy intake of 2000kcal. The fortuitous (or serendipitous) nature of healthcare needs makes it highly unpredictable, such that healthcare needs, in some instances, could be catastrophically expensive. Therefore, whereas it might be reasonable to expect that people are able to use their private share of income and wealth to provide adequately for their own food, clothing and shelter; the same cannot be expected for goods like healthcare services. This is why the provision of basic healthcare services is a collective obligation by society as a whole (especially public authorities), which is grounded in the egalitarian theories of justice as well as the right-based approach to healthcare (discussed in Sections 2.2.1 and 2.2.2), and internationally promoted by the UHC agenda of the SDGs (discussed in Section 2.2.3).

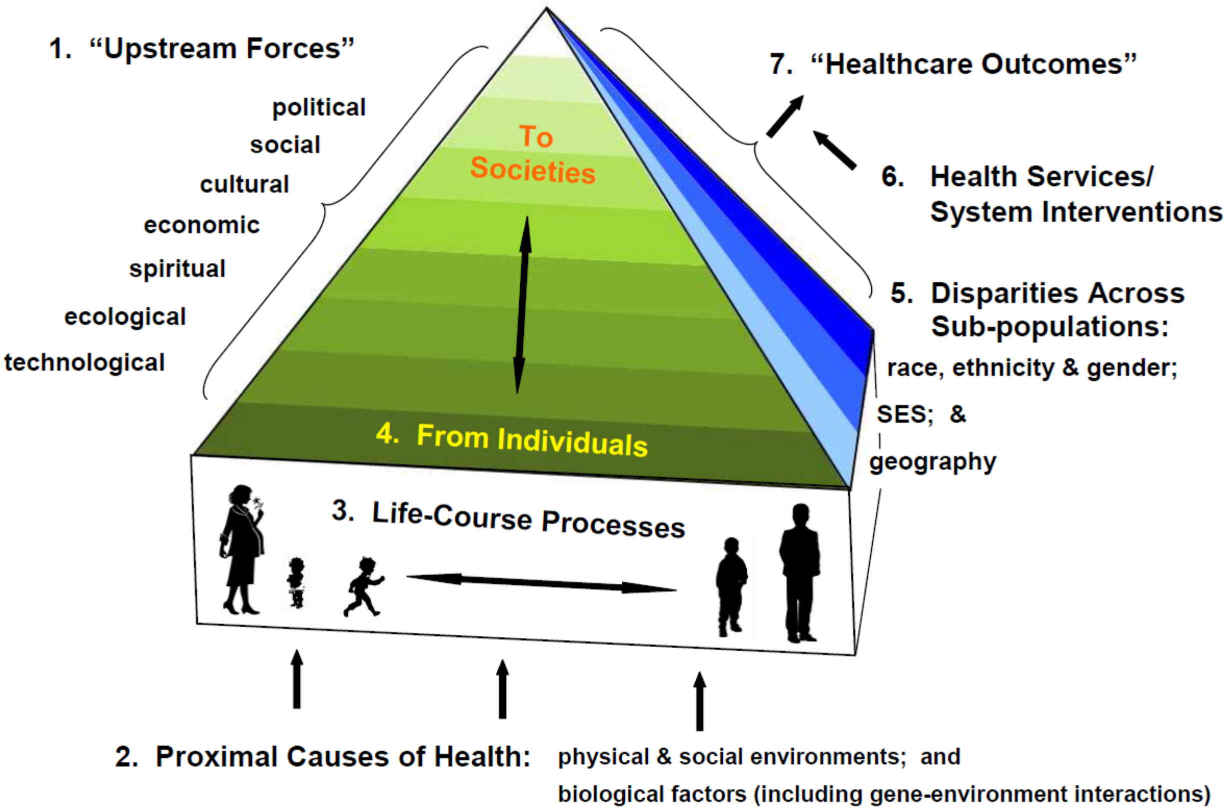

Figure 2-1 Canadian Institutes of Health Research—Institute of Population and Public Health (CIHR-IPPH) conceptual framework of population health (Etches et al., 2006, p. 34).

The concept and assessment of health(care) need are contentions (Frankel, 1991; Bowling, 2014b). Need is ascribed different meanings in various situations, such as public health, health economics and politics, or social welfare. For example, public health is concerned with population (group) health(care) needs and develops strategies for disease prevention and health promotion. This is akin to the Primary Healthcare approach discussed in Section 2.2.3. Health economists focus on meeting marginal health(care) needs in an efficient manner; hence their approach is mainly based on utilitarian principles of distributive justice, popularized by Jeremy Bentham (see Section 2.2.2.1). Political considerations of basic health(care) need emphasize equity and fairness in the provision of public benefits (or social welfare) such as primary healthcare services and are often premised on egalitarian principles of distributive justice (discussed in Section 2.2.2.2). This is discussed further in Section 2.3.3, where the controversial notions of equity and fairness are considered. Furthermore, the need for health is differentiable from the need for healthcare, even though they are interrelated (Wright *et al.*, 1998). Healthcare is one of the ways of meeting a need for health, thus healthcare need is a subset of health needs. Healthcare needs refer to health conditions that can benefit from healthcare services[12], while health needs consider the broad determinants of health, which are also dynamic (see Figure 2-1) (Lee, 2015, p. 1571). This implies that health needs are more general (than healthcare needs) because they include the potential demand for health promoting facilities (like gyms, healthy food and parks) while healthcare needs reflect the desire for healthcare facilities like (clinics and hospitals) which provide treatment and preventive services of health problems (Stevens *et al.*, 2008). The current study is concerned with assessing the need for baseline (i.e. primary) healthcare services, being an indispensable metric for equity-sensitive analysis of access to PHC. In addition to the UHC agenda, a focus on primary healthcare needs is informed by the typical resource scarcity in the study area (which is a LMIC) as well as the plethora of issues considered in Sections 1.2 and 1.4. Discussions on need assessment are featured in Section 2.3.1.4. in light of the works of relevant authors (Stevens and Gillam, 1998; Wright *et al.*, 1998; Stevens *et al.*, 2008; Kelly *et al.*, 2015).

Rather than being an absolute concept, need is a relative concept that is influenced by cultural and socioeconomic factors as well as supply-side factors. From a bio-medical perspective, need for health refers to the degree to which a patient can obtain respite or benefit from the risk of mortality and morbidity as well as from negative states of distress, discomfort, disability and handicap (Matthew, 1971; Acheson, 1978; Stevens and Gillam, 1998). Incidence and prevalence rates of disease, which are quantitative measures, are derived from this approach. In a sociological approach that constitutes a useful definition matrix of needs (Bradshaw, 1972b), Bradshaw (2005) defines: expressed need (i.e. demand); comparative/relative needs and normative need. Demand (i.e. expressed need) is a request for care that follows a feeling of need (i.e. felt need). Relative need is determined with reference to the state of health of others, while normative need is a health professional's assessment of a person's health. Consequently, normative needs may change with changes in knowledge. A person's believes and knowledge influences their felt/perceived healthcare needs, and these, in turn, are influenced by socio-economic, psychological and cultural factors (Buchan *et al.*, 1990).

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[12] A comprehensive way to define healthcare needs is disease burden, regardless of capacity to benefit from available healthcare services, because capacity to benefit is subject to value judgements such as a consideration of what outcomes are considered beneficial and by whom. The judgement of capacity to benefit is often made my clinicians and politicians whose decisions may be at conflict and/or different from patients' judgements. Capacity to benefit is also influenced by the quality of available services. An appropriate resolution of these tensions requires rigorous evidence-based research (Harrison et al., 2013).

It is apparent from the foregoing that most discussions of (healthcare) needs are matters of extensive philosophical interpretations (Harrison *et al.*, 2013, p. 574). The current research is concerned with the need for baseline healthcare services, which is influenced by the broad determinants of health illustrated in Figure 2-1. These are the basic health conditions (or disease burdens) of a population, which are likely to benefit from basic/primary healthcare services in a very cost-effective manner. Here, primary healthcare services are synonymous with the notion of Essential Healthcare Package (EHP), which ought to be context-specific, democratically determined and provided using the Primary Healthcare approach discussed in Section 2.2.3. This research is concerned with operationalizing the concept of basic healthcare needs, with a view to analyzing the accessibility of basic healthcare services in Nigeria in order to identify Medically Underserved Areas and People (MUA/Ps) for targeted interventions (Commission on Social Determinants of Health (CSDH), 2008; Carey, 2014; Carey *et al.*, 2015b; Rahman and Wazed, 2018; Eslava-Schmalbach *et al.*, 2019).

With increasing ill-health comes more need for healthcare; hence the health profile of individuals or populations is a proper medium for assessing healthcare needs (Liss, 1994, 1995). The focus of this study is on the basic healthcare needs of a population, as explained further in Chapters 5 and 6. Population health(care) needs are different from individual health(care) needs and are the basis for effective public health intervention that is the focus of the current study (Rose, 1992; Rose *et al.*, 2008). In this regard, population healthcare needs are beyond the biomedical model of illness, which mostly explains normative individual healthcare needs. Population healthcare needs are influenced by a myriad of multilevel dynamic factors, which are illustrated in Figure 2-1. In short, the determinants of health influence the health status of a population, which in turn affects healthcare needs in every context. These, together with – population capabilities, the accessibility of healthcare services, health-seeking behaviours as well as population choices, perceptions and preferences, influence the demand for and utilization of healthcare services. The concept of healthcare needs is well-elaborated by many authors (Avorn, 1983; Daniels, 1983; Stevens and Raftery, 1996; Daniels, 2007; Denier, 2007a; Fleck, 2009; Segall, 2009). The next section differentiates needs from the demand for healthcare services.

2.3.1.2 Demand for Healthcare Services

Healthcare need is different from demand (or request or expressed need), which in turn is different from utilization (or realized access) (Harrison *et al.*, 2013; Lee, 2015; Smith and Connolly, 2019). Demand refers to people's expression of a desire/interest in meeting their healthcare needs or the act/practice of requesting for healthcare services (Fries *et al.*, 1998). In contexts (such as the study area, Nigeria) where services are commercialized, demand is a reflection of people's ability and willingness to pay for healthcare services (Lee, 2015). Grossman's model[13] is a popular basis by which economists understand an individual's demand for health and medical care (Grossman, 1972, 1982; Gilleskie, 2008, p. 53). Not only is the current study concerned with group healthcare (demand), the motivation is beyond the utilitarian considerations of economists. This study is more concerned with fairness and equity, with a focus on deprived/disadvantaged groups in line with maximin egalitarian prescriptions (see Section 2.2.2). Therefore, Anderson's behavioural model (ABM) of healthcare utilization (Andersen and Newman, 1973; Aday and Andersen, 1974; Andersen, 1978, 1995, 2008) provides a more comprehensive and appropriate explanation of group demand for healthcare services in this study and is also the most cited by relevant literature (Mercuri *et al.*, 2013; Smith and Connolly, 2019). According to this model, the request for (and potential use of) healthcare services is a function of perceived needs, predisposing characteristics (e.g. demographics, social structure, health beliefs), and resources. Missing from ABM is the influence of medical practitioners on the demand and utilization of healthcare, which varies by service type (Wennberg, 2010). In this regard, health services research differentiates three types of care, namely: effective, preference-sensitive, and supply-sensitive care, with effective care being insignificantly influenced by clinicians (Goodman and Goodman, 2017). The current study is concerned with effective care, which is akin to primary healthcare. This is the healthcare to which a fundamental human right is ascribed, as discussed in Section 2.2.1 and 2.2.3.

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[13] Grossman theorized that an important component in the health production process is education. He assumes (and tested empirically) that education improves the efficiency with which an individual converts a health input into the output health.

2.3.1.3 Relationship between Need, Demand and Supply of Healthcare Services

In the context of healthcare, the relationship between need, demand and supply can be construed as being either sequential (Wright *et al.*, 1998) or overlapping (Stevens and Gabbay, 1991; Stevens *et al.*, 2004). From a sequential perspective, felt needs (or wants) lead to an expression/request for healthcare (i.e. demand), which in turn results in the determination of normative needs by a clinician. This is the perspective of the conceptual framework by Levesque *et al.* (2013), depicted in Figure 2-4. If services are available to meet normative needs, such a need is met; otherwise, there is an unmet need. An overlapping relationship amongst these constructs is more plausible because other scenarios of intersections between need, demand and supply of healthcare are tenable. Consequently, the latter is a more popular explanation in contemporary literature (The NHS Confederation, 2008; Harrison *et al.*, 2013; Lee, 2015). As illustrated in Figure 2-2, seven categories are differentiated as follows: Zone 'A' are people who need healthcare, but who (for whatever reason) neither demand nor are supplied with healthcare; hence, their needs remain unrecognized or neglected. Zone 'B' are people who desire/wish to request for services but do not need and are not supplied with services. Zone 'C' are people provided with services but do not need or demand such. Various dimensions and extent of overlaps are expressed by D – G, as explained further.

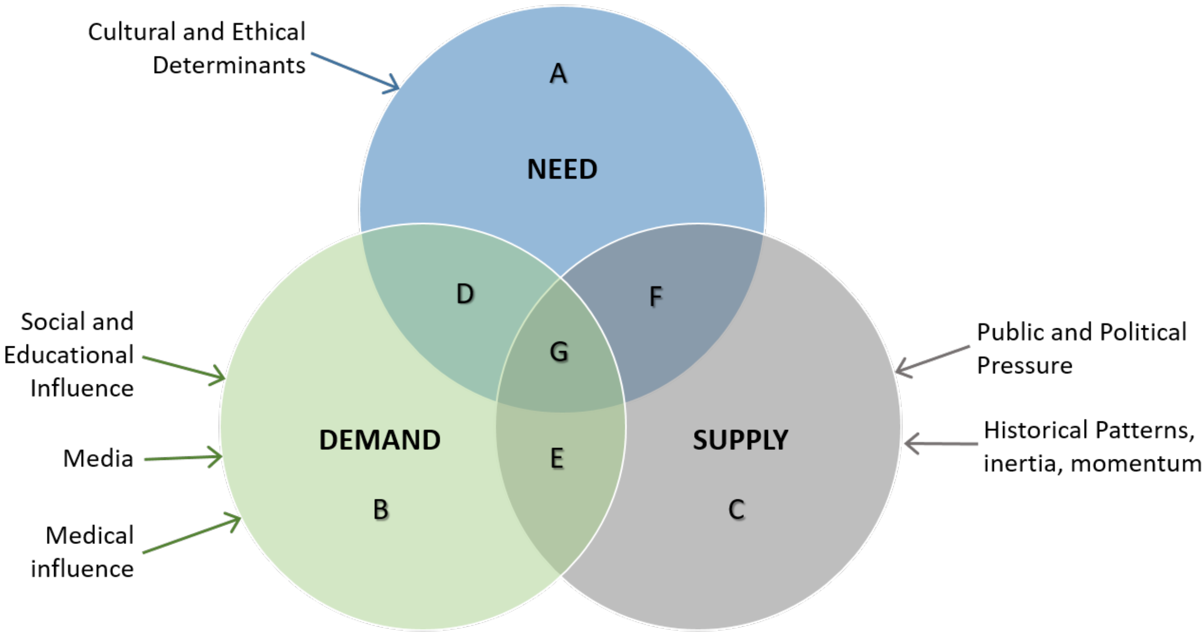

Figure 2-2 Health need, supply and demand: overlaps and influences (Stevens and Gabbay, 1991)

Needs that are expressed are illustrated by the overlap of Zone 'A' and Zone 'B'; however, Zone 'G' signifies met need (i.e. realized access or utilization), while Zone 'D' connotes unmet need. Some examples of services in Zone 'D' include need for abortion and patients on waiting lists. Services that meet a legitimate need but are unwanted or unvalued are represented by Zone 'F'. Some examples include health promotion, some screening, or a terminally ill patient being treated in an acute hospital setting. Zone 'E' are services that meet demand but do not meet a need. In other words, these are wrong/poor or ineffective treatments or prescriptions. Prescribing antibiotics for cold is a classic example of a Zone 'E' service. This study is primarily concerned with the overlap between need and supply (i.e. accessibility: Zones F and G) regardless of the demand for and utilization of available services. This is because optimal accessibility facilitates service utilization and, by extension, improves health status, all other things being equal. Nevertheless, the overall objective of public authorities is to achieve an optimal field of service access (i.e. Zone 'G', where Need, Supply and Demand match/overlap).

Clearly, health needs are influenced by a myriad of factors which are explained by various theoretical and conceptual models/frameworks, one of which is illustrated in Figure 2-1. Health needs assessment is discussed in the next section.

2.3.1.4 Assessment of Health and Healthcare Needs

Health Needs Assessment (HNA) refers to systematic approaches aimed at understanding the health needs of a local population with a view to planning and delivering effective and equitable interventions (Wright *et al.*, 1998; Collins, 2015). The intervention of concern to the current study is equitable accessibility to primary healthcare. As discussed in Section 2.3.1.1, health needs are broader than healthcare needs with health needs considering the broad determinants of health while healthcare needs are a more precise health needs estimation, which takes into account the capacity to benefit from healthcare. Healthcare needs assessment is therefore a subsidiary of health needs assessment. While Stevens and Gabbay (1991) is the first comprehensive discussion of healthcare needs and their assessment, an extensive discussion on HNA is outside the scope of the current thesis but is well-documented (Stevens and Gillam, 1998; Stevens *et al.*, 2004, 2008; Cavanagh and Chadwick, 2005).

The estimation of health needs in the current study is population-based or demographical, deriving mainly from well-established determinants of health. This is in contrast to needs estimations based on disease epidemiology, which is more consonant with the biomedical model of health (Goodman and Goodman, 2017). This also suggests that demographical estimations of need are more relevant to population (i.e. group or public) health while disease epidemiology approaches are consistent with measures of individual healthcare needs. It is therefore not surprising that the current study, which takes a public health perspective, favours the demographic approach. This distinction also reflects the dichotomies in the two main strands of health geography highlighted in Section 1.1, namely: Geographies of Healthcare and Spatial Epidemiology.

Population surveys and administrative (census) data are used for the small-area needs assessment of this study with a view to enhancing demand through PHC reorganization to facilitate better service accessibility. In this regard, group healthcare needs assessment is conducted at an optimum scale for primary healthcare services. This scale of analysis is the target threshold population of PHC services in the study area, which is 15,000 persons (NPHCDA, 2012). An optimum analytical zoning system that meets this requirement is developed in Chapter 4, using a robust automated zone design methodology. Two levels of needs assessment are performed in this study. The first is a general needs assessment for population subgroups based on the adopted baseline healthcare services of the study area. This is derived from the aggregation of relevant gridded demographic data for each synthetic analytical zone and forms the bases for analyzing accessibility of the majority of baseline healthcare services in this study, as discussed further in Chapter 6. The second needs assessment is for sexual and reproductive health as well as HIV services which require multivariate techniques. This is performed using spatial microsimulation discussed in Chapter 5. One rationale for this is that the comparative needs for HIV services in the study area ought to inform the allocation of HIV services amongst optimally organized PHC facilities. In being inclusive of and sensitive to the perspectives of socially excluded groups, perceived healthcare needs, and discursive experiences, as well as the expectations of MUA/P are also considered in this study (see Chapter 7). In this way, both quantitative and qualitative health needs assessment approaches are integrated in the spatial mixed methods research design of this study (Cavanagh and Chadwick, 2005, p. 61).

The next section discusses access and accessibility, of which ‘access as fit’ (Frenk, 1992) is consonant with the zone of intersection of need, supply and demand for healthcare services, in Figure 2-2 (Zone G), as discussed in Section 2.3.1.3.

2.3.2 Access and Accessibility of Healthcare Services

As established in Section 2.2, healthcare accessibility is important to the extent that health(care) is crucial. It is therefore not surprising that it is one of the main targets of SDG 3 (i.e. Target 3.8). Moreover, unlike health status, it is an aspect that policy makers and planners can tweak with a view to actualizing the desired outcome, good health status. However, healthcare access is a complex, multidimensional and dynamic concept whose meaning has not only been subject to many interpretations but has also evolved over time (Gulliford *et al.*, 2002). This explains why several conceptual frameworks abound in the literature, with a view to unpacking and explaining its meaning (Fortney *et al.*, 2011; Jacobs *et al.*, 2012; Cabieses and Bird, 2014; Saurman, 2016). This section briefly traces its evolution, clarifies some confusion in its meaning and explicates its current normative and operational meanings for the current study.

Healthcare access is a broad concept, which incorporates multiple dimensions including accessibility. Many studies do not make this clarification, resulting in a conflation of the two terms (Frenk, 1992). Access[14] is best understood as the 'fit' between population (and individual) healthcare needs and the healthcare system, achieved by a process of continuous adaptation (Penchansky and Thomas, 1981; Frenk, 1992). Access may therefore be construed (and measured) as the extent/degree to which a healthcare system is able to meet the healthcare needs of a population adequately and effectively. On the other hand, accessibility is the ease (and timeliness) with which a person who needs (either perceptually or objectively) and seeks care is able to obtain appropriate and effective care. Among other things, this explains why many studies of access consider a utilization dimension (i.e. realized accessibility), for it is not possible to fully measure the 'degree of fit' (i.e. access) if patients have yet to make contact with a healthcare system, owing to their inability. However, access as 'degree of fit', operationalized by contact with (or utilization of) a healthcare system is problematic in situations whereby some needy population are unable to contact a healthcare system because of their lack of accessibility and/or capability. In this study, accessibility therefore takes a "patients'-centred" perspective regardless of whether a needy person has contacted the healthcare system (Berwick, 2009; Levesque *et al.*, 2013; Waweru *et al.*, 2019). While this in itself is a sufficient measure of accessibility, it is a necessary (but not a sufficient) measure of access.

Various dimensions and explanations of access have been advanced in different literature on conceptual frameworks of healthcare access. Most of the early literature consider dimensions such as: availability, adequacy, accessibility, acceptability (or accommodation), affordability, utilization and satisfaction (Anderson, 1968, 1995; Andersen and Newman, 1973; Aday and

[14] 'Access' is a noun in this instance. Access can also be used (and/or defined) as a verb, in which case it becomes synonymous with some constituent dimensions of access (as a noun), such as utilization or effective access.

Andersen, 1974; Tanahashi, 1978; WHO/UNICEF, 1978; Penchansky and Thomas, 1981; Frenk, 1992). However, the definitions of these dimensions are sometimes vague and vary from one framework to another, such that there is no consistency in the meaning of some of these terms across disparate conceptual frameworks. Furthermore, some of the dimensions of access (such as utilization, effectiveness and satisfaction) imply an encounter with a healthcare system. Consequently, they can be considered to be outside the strict remits of accessibility, save the extent to which they help to measure and understand the 'ease or timeliness' of the encounter. More recent frameworks (Obrist *et al.*, 2007; Thiede *et al.*, 2007; Peters *et al.*, 2008; McIntyre *et al.*, 2009; Jacobs *et al.*, 2012; Cabieses and Bird, 2014) build on the classical ones by incorporating notions of capability (i.e. a broad sense of poverty) (Kinghorn, 2015; Karimi *et al.*, 2016; Clark *et al.*, 2019) and context as well as considering various/multiple options for intervention. Being robust, these frameworks are both solution-oriented and better attuned to resource-scarce LMIC contexts (like the study area, Nigeria) than the classical frameworks. In addition to the foregoing factors, most recently, frameworks of access to healthcare[15] have considered 'encounterless' healthcare services delivered using digital communication media; as well as perceived or experiential aspects and awareness (Fortney *et al.*, 2011; Levesque *et al.*, 2013; Saurman, 2016).

This research is concerned with accessibility (i.e. potential access) of primary healthcare services, with an emphasis on spatial/physical dimensions of making face-to-face contact with a healthcare system. To this end, various conceptual frameworks that are helpful in explicating both objective and perceptual (or experiential) dimensions of spatialized accessibility are invoked. Here, the emphasis is on very contemporary frameworks that are more robust (i.e. being cognizant of equity, context and culture) since they build on the classical frameworks and consider contemporary issues (such as a synergy of concrete and discursive parameters). Within this group, interventionist conceptual frameworks that consider the peculiarities of LMICs are favoured in this study, especially Cabieses and Bird (2014) and Levesque *et al.* (2013) illustrated in Figure 2-3 and Figure 2-4 below. Notice that while the former conceptual framework is broad and pays keen attention to contextual factors, the latter framework explicates proximal concerns of healthcare access. Furthermore, unlike Levesque *et al.* (2013)

[15] Several other conceptual frameworks of access have been invoked in qualitative studies. However, the majority of those frameworks are exclusively relevant to qualitative dimensions of access. Therefore, they are not very useful to a spatial MMR such as this thesis. They tend to focus only on behavioural and cultural aspects of access, and are not necessarily spatial. This study is concerned with theoretical/conceptual frameworks that are not only robust (i.e. featuring both subjective and objective dimensions), but are also sensitive to spatial dimensions.

that underscores proximal motivations for enhanced healthcare access in terms of economic productivity and increased quality of life (i.e. satisfactions), the goal of access in Cabieses and Bird (2014) conceptual framework is explicitly consonant with the values of the current research project: equity, rights to health and UHC, as shown in Figure 2-3.

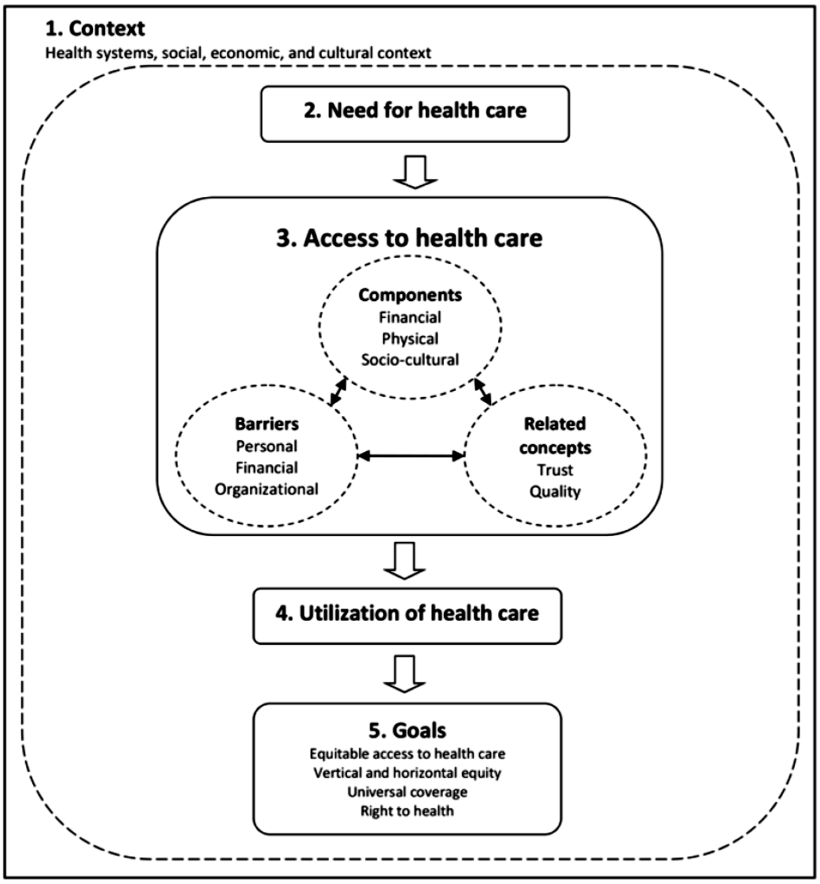

Figure 2-3 A framework of access to healthcare and related concepts for LMICs (Cabieses and Bird, 2014, p. 848)

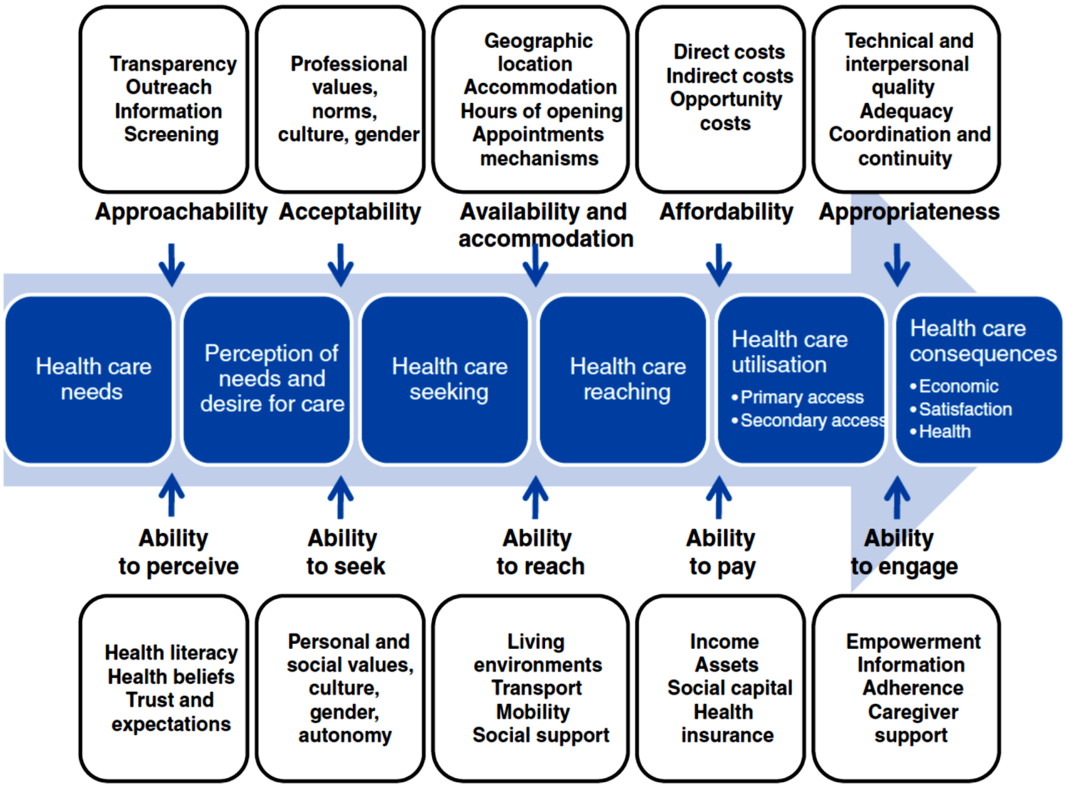

Figure 2-4 A conceptual framework of access to healthcare (Levesque et al., 2013, p. 5)

In the current study, the conceptual frameworks of Cabieses and Bird (2014) and Levesque *et al.* (2013) are held together by the 'three-delays model' (Thaddeus and Maine, 1994), which would be further discussed in Chapter 7. This is because the 'three-delays model' provides a simplified but robust analytical basis for explicating both perceived and objective healthcare needs and accessibility with adequate attentiveness to spatial and aspatial aspects as well as temporal/procedural facets of care-seeking (Myers *et al.*, 2015), as illustrated in Figure 7-1. Thus, encapsulated in the 'three-delays model' discussed in Section 7.1, the two foregoing frameworks effectively corroborate each other in this spatial mixed methods study, enabling adequate consideration of quantitative and discursive constructs and mechanisms of access which operate at multiple interacting spatial scales. The multidimensional and dynamic nature of the access conundrum necessitates the invocation of multiple conceptual frameworks/models that work in concert to illuminate various aspects of the current study. In this way, the analysis in this research project is informed by a corpus of conceptual frameworks that are relevant to the research objectives of this study. In studies wherein highly varied themes are covered, it is not uncommon for mixed methods analysis to be informed by multiple theoretical frameworks (Neale *et al.*, 2008; Jones *et al.*, 2016; Herbec *et al.*, 2018; Osei-Frimpong *et al.*, 2018; Norman *et al.*, 2019; Torres-Pereda *et al.*, 2019). In this vein, other studies have also drawn on a body of relevant literature for their qualitative data analysis

(Lovelock and Martin, 2016; Liverani *et al.*, 2017; Sychareun *et al.*, 2018). This approach is helpful in liberating a researcher from the constrictions of a single theoretical framework.

It is one thing to have sufficient overall healthcare access in an area, but it is another thing for the same healthcare access to be equitably distributed across population subgroups. As discussed in Section 2.2.3, a cardinal principle of the SDGs (and its UHC aspect) is the idea of 'leaving no one behind', which is consonant with the notion of universality aimed at minimizing inequity in health (Carey and Crammond, 2017; UNDP, 2018). The next section therefore considers equality and equity in the context of healthcare access.

2.3.3 Equality and Equity in Healthcare Access

Despite its established policy relevance as well as its preponderance in academic literature, there are confusions about the meaning of equity in health(care), as well as other related concepts, such as equality, fairness and justice (Olsen, 2011). Equality means equal division of the ***distribuendum*** (the entity to be distributed) or ***equalisandum*** (the entity of which we want an equal distribution) (Olsen, 2011). These entities could be: health or healthcare, opportunities, circumstances, basic capabilities, wealth, utility, well-being, or primary goods. In many literature, it is not always clear what the entities of interest are. In this study, the *distribuendum* is potential spatial accessibility (i.e. a quantitative index) of primary healthcare services, while the *equalisandum* is health status[16]. Crude equality in the context of health implies that health(care) resources are distributed equally regardless of health status or healthcare needs and/or personal capabilities. One problem with this is that it will result in unequal health status (or healthcare accessibility) to the extent that healthcare needs or healthcare accessibility were unequal at the outset. To counterbalance this undesirable outcome, there is a need for some value judgments (or bias), bearing the *equalisandum* in mind. This leads to discussions of healthcare equity.

Determinants of health are naturally unevenly distributed; therefore, there are variations in healthcare needs. In a broad sense, this implies that interventions aimed at enhancing health status (i.e. the *equalisandum*) should target all the determinants of health as much as possible, one of which is healthcare accessibility (CSDH, 2008; Benach *et al.*, 2013; Eslava-Schmalbach

[16] One may suggest that the *distribuendum* is primary healthcare services; while the *equalisandum* is potential spatial accessibility. However, such a framing will be more akin to pursuing equality in healthcare accessibility as opposed to equity. This is inconsistent with the principles of proportionate universalism because it does not entail a weighting of the needs of socially disadvantaged population groups, in which case the underlying drivers of inequity are not being accounted for.

et al., 2019). In this regard, the objective is not only to enhance the overall positive utility from these determinants (i.e. good health); but the social and spatial distributional dimensions of health are also important. Against this background, there are two dimensions of equity: Horizontal and Vertical Equity. In the context of the current study, **'Horizontal Equity'** is a distribution in which people with equal healthcare needs have equal accessibility to healthcare services[17]. **Vertical Equity** implies that people with more healthcare needs are given better accessibility to healthcare services in direct proportion to the extent that their needs are more. Because of its consideration of needs, equity therefore incorporates the idea of fairness[18] (Daniels, 2007; Rawls, 2009), and shows that an equitable distribution may not necessarily be equal. This doctoral thesis is concerned with actualizing an equitable distribution of spatial accessibility. Not only are healthcare services expected to be more accessible to persons with more healthcare needs, the accessibility of persons who suffer acute social disadvantages (i.e. poor) ought to also receive priority attention over that of 'not poor' persons even if their healthcare needs are the same (WHO, 1998c; Da Costa Leite Borges, 2016b, p. 153). This is the recommended type of intervention required to sustainably avert inequality in any context - an approach termed '**proportionate universalism'** (Marmot *et al.*, 2010; Carey *et al.*, 2015a). This approach proportionately counterbalances the effects of material deprivation on the poor healthcare accessibility and health status of disadvantaged population subgroups (i.e. their lower capability of utilizing accessible healthcare)[19] (Kelly *et al.*, 2007; Beeston *et al.*, 2014). This is also the position that is well-supported by the SDGs and its grounding principles because it ensures that the rate of the developmental progress of marginalized groups is faster than average groups whose progress rate is, in turn, faster than well-off groups (Stuart and Woodroffe, 2016).

From Section 2.3.2, it can be seen that access to healthcare transcends healthcare utilization (which is realized access). Consequently, it has been argued that inequalities in the use of

[17] Enhancing and equalizing only healthcare, though necessary, is not sufficient to enhance and equalize the desired outcome (i.e. health status). A sufficient condition for the enhancement and equalization of health status is that positive aspects of all the determinants of health are enhanced and equalized as well. This is however a theoretical ideal which is not easily realizable.

[18] Fairness has a generally positive connotation such that if the outcome of a contentious issue is positive, it is considered to be intuitively acceptable, right or just.

[19] The determinants of health have differential effects on a population such that if universal interventions are applied, socially advantaged groups always benefit disproportionately and vice versa (Victora *et al.* 2000). Hence remedial intervention must be both universal and proportionate as a function of the scale and intensity of disadvantage in other to counterbalance this differential rate of benefits.

healthcare would be acceptable if they result from differing preferences/choices (Mooney *et al.*, 1991; Culyer *et al.*, 1992). This dimension of inequality would be acceptable to the extent that such preferences/choices are informed decisions and are within the control of the individual. Natural variations in personality traits (which are partly genetically determined) interact with variations in the social environment and/or social class to produce variations in health-related choices and preferences, one of which is care utilization (Balia and Jones, 2008). Over time, these interactions (between genetic traits and social conditioning/culture) often crystalize health-related preferences/choices into habits, over which an individual may have limited control. Therefore, in the context of healthcare utilization, inequalities in utilization that result from informed and controllable preferences/choices in healthcare utilization, are considered deliberate, and should be acceptable (Le Grand, 1992b; Denier, 2007b). This also implies that health(care) inequalities are complicated and therefore difficult to eradicate. At best, policy measures can only aspire to diminish or minimize these inequalities as much as possible (Olsen, 2011).

By exploring many definitions of equity, Culyer and Wagstaff (1993), in an insightful early clarification, argues that an equitable healthcare distribution is one that is organized to achieve as equal a distribution of health status as is possible. Among other things, this suggests that the concept of health status is important to many considerations of equity in healthcare access more so that health status is the most important surrogate of healthcare needs. This has been discussed extensively in Section 2.3.1. When judging the extent to which variations in health is unfair, Whitehead (1991) emphasizes the necessity of focusing on the causes of inequality. In this way, 'inequity' has a moral and ethical dimension, referring to differences which are not only *unnecessary* and *avoidable*[20] but are also considered *unfair* and *unjust* (*ibid*). Consequently, in the literature, there is an agreement that amongst the determinants of health, health differences which result from biological variations (i.e. genetics) as well as informed and deliberate (i.e. controllable) health-damaging behaviour (i.e. lifestyle preferences/choices), are not really inequitable (Le Grand, 1987, 1992a; Denier, 2007b).

In sum, equity is an ethical concept that means social justice or fairness; hence, it is grounded in principles of distributive justice, which are discussed in Section 2.2.2 (Braveman and Gruskin, 2003a, 2003b). In the context of health(care), equity is popularly defined as an

[20] Further to the arguments in the preceding paragraph, variations in health status, which result from an informed and deliberate refusal to utilize 'effective care' (like PHC) are warranted, necessary and unavoidable.

absence of socially unjust or unfair disparities in health outcomes as well as its major determinants (illustrated in Figure 2-1), including healthcare accessibility. In this light, inequity means the presence of systematic disparities in health status or its social determinants between social groups with varying degrees of underlying social (dis)advantage, categorized by different positions in a social hierarchy. The consequence is that these inequities systematically perpetuate disadvantages for the same social groups that are already disadvantaged in terms of their health and other socioeconomic variables, which are essential to wellbeing and prosperity[21].

It is therefore not surprising that the concept of equity strongly aligns with the fundamental human rights to health outlined in the constitution of the WHO (1946) as well as other international human rights treaties such as: the Universal Declaration of Human Rights (UDHR 1948), especially Article 25(I); the International Covenant on Economic, Social and Cultural Rights (ICESCR, 1966), especially Article 12; the International Convention on the Elimination of all forms of Discrimination against Women (CEDAW, 1979), Article 12; and the Convention on the Right of a Child (CRC, 1989), Article 24 (United Nations General Assembly, 1948, 1966, 1979, 1989). In addition to discussions on the fundamental human rights to health in Section 2.2.1, it interconnection with equity is well-known (Braveman and Gruskin, 2003b; Newdick and Derrett, 2006). While the overall goal of this doctoral project is equitable healthcare accessibility, the current study comprehensively models small-area accessibility to primary healthcare services with a view to identifying MUA/Ps, which are theorized as being socially excluded. Perceived healthcare needs and accessibility of the excluded people/places, as well as their discursive experiences and preferences, are then considered in the qualitative strand of this study (i.e. Chapter 7). This informs an understanding of the subjective and experiential concerns of MUA/Ps with a view to informing context- and culturally- sensitive interventions (in form of evidence-based policies and practice). The remainder of this chapter considers how the foregoing principles and concepts of healthcare access have been operationalized in relevant studies.

[21] This is explained by the Matthew Effect (Rigney, 2010) which holds that in many instances, the rich get richer while the poor get poorer, thereby creating a widening gap between those who have more and those who have less. This theory of cumulative advantage was propounded by the sociologist Robert K. Merton who called this phenomenon the Matthew effect, named after a passage in the gospel of Matthew.

2.4 Current Research Issues on Accessibility of Healthcare Services

Owing to its fundamental importance and multifaceted nature, as discussed in the preceding sections, healthcare accessibility is so topical that it is actively studied across many academic disciplines and research groups. These disciplines include: Health geography, Development Studies, Health Services Research, Health Economics and Health Sociology. This section therefore grounds the current study in the existing body of literature by discussing the key geographical concerns of healthcare accessibility in select disciplines that are extremely keen on the spatial dimensions. Among other things, this shows that similar contemporary geographical concerns are shared across a myriad of disciplines. For instance, with regards to the accessibility of healthcare services, relevant academic fields agree on the need for the following even though they may pursue these objectives in different ways: (1) equitable social-spatial accessibility, based on healthcare needs, (2) optimum spatial units and scales of analysis that are consistent with the PHC phenomenon being studied (3) context-sensitivity with cultural appropriateness of PHC services. This section therefore aims at situating this study in these broader fields, by highlighting current research trends and underlining contemporary inadequacies and limitations which the current study addresses. The remainder of this section considers the place of this thesis in two (2) main academic fields, namely: Development Studies and Health Geography.

2.4.1 Development Studies

In addition to favouring more context-specific knowledge claims, the increasing use of meso-scale and finer resolution datasets for addressing relevant cause-and-effect linkages is one of the contemporary hallmarks of development studies (Hoogeveen *et al.*, 2014; Currie-Alder, 2016). At the heart of the SDGs (as well as its UHC component) is the concept of equity, which emphasizes 'leaving no-one behind', by disaggregating data according to PROGRESS stratifiers (O'Neill *et al.*, 2014; Freistein and Mahlert, 2016; UNDP, 2018). The MDG era came under much criticisms for, among other things, focusing on national-level estimates which mask/conceal within-country health(care) inequalities, thereby being of limited relevance to within-country local-level managerial decision making (Cuadros *et al.*, 2017). Spatial data analysts are therefore keen on developing Small-Area Estimation (SAE) methods to support the within-country spatial allocation of health resources, thereby aiding local-level planning to guide resource allocation, managerial decisions and performance assessment (AbouZahr *et al.*, 2017, p. 12; Anderson *et al.*, 2017). To this end, the development of advanced methods of

SAE of development-related indicators is a crucial policy-relevant activity which this research project advances[22]. This advancement in the SAE methods is discussed further in Section 3.3.2.

Together with the foregoing assertions, the concept of '**platform**'[23] is an important organizing framework for making major health-related investments (Stenberg *et al.*, 2017). From the perspective of (social) development (especially UHC), a 'platform' is defined as logistically related delivery channels through which interventions can be appropriately, effectively, and efficiently delivered (Watkins *et al.*, 2018, p. 46). There are five types of platforms, namely: Population-based health interventions, community services, health centres, first-level hospitals, and referral and specialized (second- and third-level) hospitals[24]. Despite this differentiation, what is common to all types of platforms is the regional (i.e. zoning) dimension. For instance, a Health Service Area (HSA) is the region (or epidemiological environment) of a hospital that serves as a 'platform' for the delivery of logistically related health interventions which address a myriad of public health problems. In contrast to the individual interventions themselves, these platforms often serve as natural units of investments and for cost estimation as well as for analysis of cost-effectiveness of public interventions, Development Assistance for Health (DAH) and health system investments (Jamison *et al.*, 2018). It is also the theatre for analyzing the context-sensitivity and cultural appropriateness of relevant health-related interventions. Hence, the notion of platform is relevant to quantitative, qualitative and mixed methods analysis of health-related studies. It is therefore not surprising that the World Bank (through its Disease Control Priorities in Developing Countries (DCP) initiative), as well as the WHO, continue to use platforms as an important organizing concept for making major health-related investments (Stenberg *et al.*, 2017). Insofar as the concept of 'platform' is important to health systems strengthening (and by extension UHC and SDG initiatives), optimized small-area zones and small-area estimation of standard healthcare indicators are important to the current study. These are discussed further in Sections 3.3.1 and 3.3.2, respectively.

[22] For these reasons, advanced methods, such as Bayesian geospatial modelling, are now being used by many international initiatives (like the Institute of Health Metrics and Evaluation (IHME)), for small-area estimates at fine spatial scales.

[23] See also Section 2.2.3

[24] See Watkins *et al.* (2018, p. 46)

2.4.2 Geographies of Healthcare Services

Parallel with the foregoing concerns of development studies, geographers have been interested in the accessibility of healthcare services since the earliest works (Morrill and Earickson, 1968; Pyle, 1971; Shannon and Dever, 1974; Joseph and Phillips, 1984; Jones and Moon, 1987)[25]. Within this field, health Geographers are keen on understanding variations in accessibility and utilization of healthcare services in particular, as well as other health-related concerns of geographical relevance. In this regard, literature reviews on key concerns of the sub-discipline abound (Guagliardo *et al.*, 2004; Higgs, 2004; Ricketts, 2009; Terry *et al.*, 2013; Lyseen *et al.*, 2014; Rosenberg, 2014, 2016). Other reviews focusing on LMICs have considered healthcare access of select vulnerable groups and/or service types, such as people with disabilities (Bright and Kuper, 2018; Bright *et al.*, 2018b), children (Bright *et al.*, 2017, 2018a) and obstetric care (Kyei-Nimakoh *et al.*, 2017; Wong *et al.*, 2017; Tegegne *et al.*, 2018). A cardinal motivation for the current study is that "in the developing world research should focus on the generation of more locally relevant and precise estimates of geographical access and their relationship to health outcomes" (Tanser *et al.*, 2010, p. 560).

In health and transport geography, the traditional focus of the literature on healthcare accessibility is on concepts, methods and applications (van Wee, 2016). More recently, there is an increasing awareness of, and critical engagements with theorizations of healthcare access inspired by the broader 'cultural turn' in human geography and social sciences (Gesler and Kearns, 2002; Parr, 2003; Dorn *et al.*, 2010; Johnston and Sidaway, 2016a, p. 245). To this end, it is desirable that the level of theoretical advancements in healthcare geographies catch up with methodological advances that are currently more rapid (Rosenberg, 2014). This is a healthy development insofar as the outcomes of these practices are helpful in informing better understandings of underlying causal processes, with a view to solving empirical problems by influencing relevant policies and practices. Solution-oriented research projects (as opposed to basic science inspired by curiosity) are particularly relevant to LMICs that are laggards in meeting the SDGs, including their health-related targets of UHC. Similarly, studies that consider vulnerable population sub-groups or a particular type of healthcare service are often motivated by the UHC agenda of the SDGs, especially when the spatial focus is LMICs (see for example Bright *et al.* (2018b), Wong *et al.* (2017)). The current study continues in the health geography tradition of making methodological advancements, but at the same time is

[25] For a brief history of health geography, see Emch, *et al.* (2017, pp. 9 – 17).

sensitive to contemporary theoretical concerns, as well as advocating for marginalized and underserved places and people in the study area (i.e. MUA/Ps, see Chapter 7).

The primary motivation for accessibility studies in geography is to offset the distance-decay effect as much as possible. Distance-decay suggests that with greater distance to healthcare facilities comes less likelihood of services' utilization (Ambery and Donald, 2000; Hippisley-Cox and Pringle, 2000; Field and Briggs, 2001; Reilly *et al.*, 2001), as well as increased inequalities in areal health status (Hewko *et al.*, 2002; Haynes, 2003). Improved accessibility therefore results in enhanced healthcare utilization, with the effect that overall population health is enhanced. This has been expanded into considerations of access beyond the narrow remits of distance. In this regard, disparities in access are shown to affect healthcare utilization as well as health outcomes, such that with lower accessibility comes a reduction in utilization by the needy population (Dai, 2010; Bissonnette *et al.*, 2012). To this end, health geographers are at the forefront of developing, advancing and implementing geographical methods in the analysis of healthcare accessibility. Health geographers are also adept at explicating the spatial dimensions of healthcare accessibility by applying relevant socio-spatial theories across post-positivist and interpretive theoretical fields. The current research project continues in this tradition.

As with other research fields, concerns with zoning designs are also prevalent in the analysis of spatial accessibility. For instance, it is crucial to select appropriate spatial units in order to minimize aggregation errors (Hewko *et al.*, 2002; Langford and Higgs, 2006; Apparicio *et al.*, 2008, 2017). Owing to increased population dispersal around the centroid of zones, these error types are more common with large and less compact zones. This is discussed further in Section 3.3.1 and operationalized in Chapter 4.

A current concern with accessibility is a need to integrate objective and subjective dimensions of healthcare access in order to capture the complex and multidimensional nature of the phenomenon (van Wee, 2016; Cabrera-Barona *et al.*, 2017). Research has shown that there are socio-spatial inequalities in the accessibility of healthcare resources in many contexts (Goodman *et al.*, 2010; Asaria *et al.*, 2016), including the study area, as explained in Section 1.2. A popular observation is that affluent and/or urban areas have better accessibility than low-income and/or rural areas. In order to achieve territorial/spatial justice in any context, there is therefore a need to understand the extent and characteristics of variations in the accessibility of healthcare services, with a view to identifying marginalized places and people.

In Chapter 7, the doctoral research project therefore uses qualitative methods to explicate the experiential and perceptual aspects of potential spatial accessibility of people in places of extreme healthcare deprivation. This is further to the identification and characterization of Medically Underserved Areas/Persons (MUA/Ps) and Health Professional Shortage Areas (HPSAs) in Chapter 6 (Wang and Luo, 2005; Ricketts *et al.*, 2007; Streeter *et al.*, 2020). Thus, Qualitative methods constitute the second phase in the Spatial Mixed Methods Research (SMMR) design of this thesis, as discussed further in Section 3.1.

2.5 Summary of Literature Review

This doctoral thesis is grounded in and contributes to various interrelated bodies of knowledge, especially: (1) geographies of healthcare services, (2) development studies, and (3) Small-Area Variation Studies (SAV) (of health services research). Among other things, these bodies of knowledge are fixated on the geographical dimensions of healthcare. For instance, although the need for optimized zoning systems is an enduring matter in human geography and spatial/location science, development studies and SAV studies are recently becoming mindful of the extraneous spatial effects of suboptimal aggregation zones. The rationale for enhanced, efficient and equitable (i.e. optimal) spatial accessibility to essential healthcare services is founded on three main principles: (1) Egalitarian principles of distributive justice[26], (2) fundamental human rights to health(care) and (3) the universalism aspiration of SDG 3, especially target 3.8[27], which is synonymous with the UHC goal (Jamison *et al.*, 2013; WHO, 2014). Pursuant to the UHC agenda, it is crucial for governments (especially in LMICs) to provide a modicum of (free) PHC services termed Essential Healthcare Package (EHP) or Health Benefits Package (HBP), which are context-specific and delivered in prioritized order (Glassman *et al.*, 2016; Watkins *et al.*, 2018). Accessibility to these services should be needs-based while simultaneously prioritizing poor/vulnerable subgroups (WHO, 1998c; McGillivray *et al.*, 2011; Benach *et al.*, 2013; Da Costa Leite Borges, 2016b, p. 153; Carey and Crammond, 2017). The importance of small-area geographies, as well as context-specific and inclusive research evidence is underscored in development studies (and UHC), health geography and

[26] Egalitarianism underscores an equitable needs-based distribution of resources. It is founded on the aristocratic principle of equal treatment for equal needs (horizontal equity) and unequal treatment for unequal needs (vertical equity). These positions are better supported by Keynesian economics in contrast to the dominant neoliberal economics which is one of the main drivers of contemporary inequalities.

[27] The notion of solidarity (i.e. altruism) is implied by egalitarianism, group rights and UHC's universalism, such that some basic/crucial (healthcare) needs ought to be unconditionally (and freely) provided by national governments for everyone, with preferential treatment for disadvantaged and/or less capable subgroups.

SAV studies (Currie-Alder, 2016; Kim *et al.*, 2016; Jamison *et al.*, 2018; Pinzari *et al.*, 2018). On the one hand, this foregrounds a need for mixed methods studies that not only consider the concrete (measurable) and discursive (nuanced) perspectives of healthcare but are also explicitly spatial, localized and context-specific. On the other hand, not only is there a need to disaggregate research findings by relevant socioeconomic markers, especially the PROGRESS stratifiers (Johnson, 2010), it is necessary to utilize small-area zones which are optimized for analytical purposes (Kim *et al.*, 2016; Pinzari *et al.*, 2018). Therefore, in the literature, there is a continuous trend of developing increasingly advanced and robust methods that are adept at handling these complex and multidimensional aspects of the UHC challenge. However, the empirical operationalization of these aspirations remains a major challenge, especially in LMIC contexts that lack quality datasets and technical know-how for precise fine-scale development interventions (Glassman *et al.*, 2014; Stuart *et al.*, 2015; Health Data Collaborative (HDC), 2019). Consequently, there is a dearth of robust fine-scale studies of spatial accessibility to PHC services in LMICs (especially Nigeria), hence the need for innovative approaches such as the current study. Not only are existing studies conducted at very coarse or inappropriate spatial scales as well as being sometimes methodologically defective, they also neither incorporate the nuanced (cultural) perspectives of inhabitants of their local contexts nor consider the equity dimensions of spatial accessibility (by appropriate socio-spatial data disaggregation). They also either focus on only a single healthcare service or consider accessibility to healthcare facilities without accounting for the quantity (and quality) of specific services therein. In this way, they are of limited relevance to PHC polices (and by extension, the UHC agenda), which ought to consider a modicum of prioritized context-sensitive healthcare services, the Health Benefits Package (HBP). The current study overcomes these limitations to a great extent.

Drawing on the various bodies of literature relevant to this thesis, the next Chapter (3) discusses how the empirical concerns of this study have been addressed in existing works. This exploration considers studies that use statistical, spatial, qualitative and mixed methods. In the same chapter, the SMMR design of this study is explicated. Among other things, the next chapter argues that in the context of this study, SMMR design is superior to the mono-methods or aspatial mixed methods methodology employed by most existing studies.

Chapter 3. Research Methodology: Spatial Mixed Methods Research Design

3.1 Background

This chapter details the methodology for meeting the research aims and objectives outlined in Section 1.3. It begins with the research design of this project, including its strengths and limitations as well as the incorporation of GIS. Thereafter, the types and sources of data used are explained. Subsequent sections discuss specific methods for meeting each of the objectives of this research as well as their critiques and limitations. The last section highlights the advantages of this methodology over those employed by similar research projects.

3.1.1 The Research Design: A Mixed Methods Research (MMR)

This project employs a mixed methods research design in order to benefit from a synergy of quantitative and qualitative research methods (Barbour, 1999; Gatrell and Elliott, 2015a). The definition of mixed methods research designs is a contentious matter; as such several definitions have been advanced (Pluye and Hong, 2014; Hesse-Biber and Johnson, 2015; Creswell and Clark, 2018b; Meixner and Hathcoat, 2019). Many of these definitions can be found in a highly cited journal article by Johnson *et al.* (2007), with recent commentaries by Creswell and Clark (2018b). According to Johnson *et al.* (2007, p. 123), "Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the purposes of breadth and depth of understanding and corroboration". Combining 'the power of stories and the power of numbers' (Pluye and Hong, 2014, p. 30), mixed methods research is "an approach to research in the social, behavioural, and health sciences in which an investigator gathers both quantitative (closed-ended) and qualitative (open-ended) data, integrates the two, and then draws interpretations based on the combined strengths of both sets of data to understand research problems" (Creswell, 2015, p. 2). Even though it typically refers to the use of quantitative and qualitative methods in one study, a series of studies addressing the same research problems/questions using these two research paradigms can be considered mixed methods research (Polit and Beck, 2004; Lund, 2012; Anderson, 2016, p. 233; Johnson and Christensen, 2016, p. 988; Creswell and Clark, 2018b). This doctoral thesis endorses the idea that mixed methods research designs possess the following core characteristics (Creswell and Clark, 2018b, p. 63; NIH Office of Behavioral and Social Sciences Research, 2018, p. 7):

- Address research questions that necessitate multiple perspectives, contextual understanding of real-life issues and cultural influences;
- Both qualitative and quantitative data are collected and rigorously analyzed in response to research questions and hypotheses. The magnitude and frequency of constructs are analyzed quantitatively, while qualitative analysis considers the meaning and understanding of the constructs;
- These two forms of data and their results are integrated (or mixed or combined) in order to maximize the strengths and counterbalance the weaknesses of each data type;
- The foregoing procedures are organized into specific research designs that provide the methodology and logic for conducting the study, and
- These procedures are framed within theory and philosophy.

The foregoing therefore informs the design and organization of this methodology chapter.

In the social sciences, quantitative research is grounded in the postpositivist epistemology (Teddlie and Tashakkori, 2009, p. 66), and in the context of health geography, the emphasis is on the measurable and the observable, employing methods of mapping, spatial analyses and statistics (Gatrell and Elliott, 2015a). The motive is often to describe and then explain spatial patterns, with a view to making plausible generalizations and developing scientific laws or models. On the other hand, qualitative research works derive from the interpretative or constructivist epistemology, aspiring rather to interpret and better understand a phenomenon of interest by paying due attention to the values, feelings, beliefs, experiences and attitudes of research participants. Individually, quantitative and qualitative methods have limitations, which are compensated for by mixed methods (Barbour, 1999). Consequently, "a rounded health geographer should be familiar with both qualitative and quantitative methods, not least because in many instances a research study calls for both to be used" (Gatrell and Elliott, 2015a, p. 66).

Against this background, the majority of equity-sensitive analyses and modelling of socio-spatial disparities in healthcare services are done with positivist epistemologies using methods of statistics and spatial analytics. This is implied by the international prescription to disaggregate equity-sensitive studies by the multidimensional stratifier, PROGRESS (Kavanagh *et al.*, 2008; O'Neill *et al.*, 2014; Attwood *et al.*, 2016). Interpretative approaches are often complementary, entailing the collection and analysis of qualitative data types in order to provide nuanced perspectives and explanatory depths to the findings from the spatial analysis. In this light, the qualitative data analysis of this thesis is useful, among other things, for explaining findings from the quantitative and spatial data analysis sections, including plausible explanations for findings that may be unexpected or anomalous. It is well-established that in health and social sciences, mixed methods designs are superior to either qualitative or quantitative methods despite a few limitations discussed further in Sections 3.1.2 and 3.1.3.

There are various types of mixed methods research designs, such as: convergent parallel design, explanatory sequential design, exploratory sequential design, intervention design, hybrid design, embedded design, transformative design, and multiphase design (Pluye and Hong, 2014; Johnson and Christensen, 2016; McBride *et al.*, 2019; Meixner and Hathcoat, 2019). This doctoral research project implements an explanatory sequential mixed method research design (Creswell and Creswell, 2017), in which quantitative methods are typically dominant and precede qualitative methods (Morse, 2003; Brannen, 2005; Creswell and Clark, 2018a; McBride *et al.*, 2019, p. 699; Meixner and Hathcoat, 2019, p. 63). These types of studies are conducted by first collecting and analyzing quantitative data whose results are built upon to further collect and analyze qualitative data, which in turn are useful in explaining the findings from the original quantitative data analysis. This research design is adept at overcoming the limitations and critiques of quantitative/spatial methods in addressing research problems/objectives (like spatial accessibility and inequalities) that are traditionally in the domain of quantitative methods. However, whereas conventional mixed methods research are concerned with integrating conventional quantitative methods (i.e. statistics) with qualitative data types and methods (Tashakkori and Teddlie, 2010), this thesis integrates a corpus of advanced spatial analytics with qualitative methods. Therefore, it is a special type of explanatory sequential mixed methods design with explicit geographical advantages and relevance. This type of MMR design is operationally be called Spatial MMR as discussed further in Section 3.1.3. Before that, the strengths and downsides of conventional mixed methods are considered in the next section.

3.1.2 Rationales and Limitations of Mixed Methods Research Designs

Traditionally, researchers have employed either a quantitative or a qualitative research approach, but not both approaches simultaneously in addressing a research objective or problem (Wiggins, 2011). However, there is now an increased awareness and acceptance of the compatibility and complementarity of these two research approaches for addressing research problems in the social sciences. Routines of our everyday lives also give credence to the use of mixed methods as an intuitive way of doing research (Creswell and Clark, 2018b). Many aspects of professional life provide examples that feature the combination of quantitative and qualitative information. For instance, in choosing a course of action, politicians use the personal stories of their constituents in tandem with the statistical trends from their districts. When making a diagnosis and treatment plan, physicians consider quantitative lab results along with patients' qualitative life history and symptoms.

Individually, quantitative and qualitative methods have limitations and critiques that are offset by combining both research approaches (Tashakkori and Creswell, 2007; Wiggins, 2011; Johnson and Christensen, 2016). Since the individual strengths and limitations of qualitative and quantitative methods are well-known (Johnson and Onwuegbuzie, 2004; Johnson and Christensen, 2016; Creswell and Clark, 2018b), the remainder of this section summarizes the advantages of mixed methods which are expounded by other authors (Greene *et al.*, 1989; Johnson and Onwuegbuzie, 2004; Onwuegbuzie and Leech, 2005; Collins *et al.*, 2006; Kelle, 2006; Lund, 2012; Johnson and Christensen, 2016; Creswell and Clark, 2018b). Researchers are able to combine the 'empirical' precision and 'descriptive' prescription of quantitative and qualitative methods respectively, by employing a mixed methods research design (Onwuegbuzie, 2003; Onwuegbuzie and Leech, 2005). With mixed methods research, it is possible to achieve a more nuanced analysis of research objectives or problems than can be achieved by a single method alone (Azorín and Cameron, 2010; Anderson, 2016). Through the collection, analysis, and interpretation of quantitative and qualitative data, mixed methods research designs result in a thorough understanding of complex phenomena (Meixner and Hathcoat, 2019, p. 57). By simultaneously drawing on multiple data types, the trustworthiness or validity of research inferences, explanations and assertions are enhanced through the mutual confirmation of findings. Not only is a deep understanding of the phenomenon of interest fostered by mixed methods research, the development of culturally appropriate instruments (or policies or interventions) is also facilitated (Bartholomew and Brown, 2012).

Thus, with mixed methods designs, deeper interpretation of variables, exploration of causal mechanisms, and contextual factors that may moderate or mediate a research problem or objective can be provided (Azorín and Cameron, 2010; Bartholomew and Brown, 2012; Anderson, 2016). It is therefore not a surprise that following the first and second methodological developments of quantitative methods and qualitative methods respectively, mixed methods research has been acclaimed by many authors as: the "third methodological movement" (Tashakkori *et al.*, 2003, p. 5), the "third research paradigm" (Johnson and Onwuegbuzie, 2004, p. 15), and "a new star in the social science sky" (Mayring, 2007, p. 1).

Mixed methods research designs are not without some downsides that are important to consider. They are more complex than mono-methods research projects (Anderson, 2016, p. 236; Johnson and Christensen, 2016, p. 1006); therefore, it can be difficult for a single researcher to implement both qualitative and quantitative methods in a single study (Johnson and Onwuegbuzie, 2004; Azorín and Cameron, 2010; Creswell and Clark, 2018b, p. 86). Consequently, it is advisable for mixed methods research to be conducted by a team of researchers (i.e. multidisciplinary teams), especially in equivalent designs (i.e. mixed methods research in which qualitative and quantitative methods have equal weights) (Curry *et al.*, 2013, p. 121; Johnson and Christensen, 2016; McBride *et al.*, 2019). Furthermore, the resources and research duration of many postgraduate academic programmes (and the length of their associated dissertations/theses) tend to have been set with mono-method research designs in mind (Johnson and Onwuegbuzie, 2004, p. 14; Onwuegbuzie and Leech, 2005, p. 382; Teddlie and Tashakkori, 2009, p. 279; Hesse-Biber, 2010, p. 213; Pearce, 2015, p. 54; Johnson and Christensen, 2016, p. 1003). This is inferred because traditional education curriculums and research trainings promote methodological purism. This challenge is more daunting with spatial mixed methods designs like the current study, which incorporates a corpus of advanced spatial analytics, as discussed further in Section 3.1.3.

Because of a need to collect and analyze both qualitative and quantitative data in a single study, mixed methods research typically require more time and resources than mono-methods research (Johnson and Onwuegbuzie, 2004; Azorín and Cameron, 2010; Anderson, 2016; Johnson and Christensen, 2016; Creswell and Clark, 2018b; NIH Office of Behavioral and Social Sciences Research, 2018; McBride *et al.*, 2019). The analysis and interpretation of eclectic data types could sometimes be problematic or challenging (Anderson, 2016; NIH Office of Behavioral and Social Sciences Research, 2018; McBride *et al.*, 2019). For instance, individual or multi-expertise teams may be biased towards a particular strand of methods, especially if they lack sufficient mixed methods experience. The specifications of rigour are different for quantitative and qualitative methods[28] (Preissle *et al.*, 2015, p. 147; McBride *et al.*, 2019, p. 709); therefore, the ability to strictly follow the guidelines of each type of method could be challenging (Green and Thorogood, 2004a, p. 191; Morse, 2018; Tong and Craig, 2019). Furthermore, in some mixed methods research designs, especially the equivalent ones, contradictory or divergent or conflicting findings could be derived from the two strands of methods, which could be both a strength and a weakness (Lund, 2012; Johnson and Christensen, 2016; NIH Office of Behavioral and Social Sciences Research, 2018). For example, with mono-methods research, a researcher could be oblivious of multiple/various understandings of a research problem or phenomenon (Johnson and Christensen, 2016, p. 1006). However, with mixed methods like the current study, contradicting or divergent findings are a basis for further reflection, revision of research hypotheses, as well as further research; with a view to generating new insights (Lund, 2012, p. 4; NIH Office of Behavioral and Social Sciences Research, 2018). It is challenging to publish mixed methods studies because of the page and word count limits of journals as well as the scarcity of journals interested in these types of research designs (Azorín and Cameron, 2010; Anderson, 2016; McBride *et al.*, 2019).

The foregoing suggests that most of the limitations of mixed methods research are pervasive in the equivalent and/or concurrent variants, in which quantitative and qualitative facets are ascribed equal weights, unlike the current study. As discussed in Section 3.1.1 above, this study employs an explanatory sequential mixed methods design in which quantitative methods (comprising statistics and spatial analytics) are dominant and precedent (Creswell and Clark, 2018a; McBride *et al.*, 2019, p. 699; Meixner and Hathcoat, 2019, p. 63). In this way, the matter of limited researcher skills is also mitigated in that the dominant methodological strand of this thesis is spatial analytics, which is the primary area of proficiency of the researcher. In addition to this, complementary trainings in qualitative and mixed methods research were undertaken by the researcher (in the course of his doctoral programme) in order to be able to satisfactorily conduct the qualitative strand and integrate both methods. This conforms with the recommendations of prominent mixed methods authors (Creswell and

[28] See also Section 3.4.6

Clark, 2018b, p. 86; NIH Office of Behavioral and Social Sciences Research, 2018, p. 16). To subvert the limitations of time and resources, the qualitative data collection facet of this study was tailored to fit the research design of this project. Essentially, this entailed conducting an optimal number of group discussions which were targeted at only the healthcare deserts, as discussed further in Section 3.4.2. Analytic and interpretive issues derive mostly from limited skills of researchers and partly from the typical complexity of mixed methods research designs. Not only are these issues minimal with the explanatory sequential type of mixed methods design employed in the current thesis, but they are also adequately mitigated by ensuring that the researcher acquired sufficient trainings in relevant eclectic methods.

3.1.3 Spatial Mixed Methods Research Designs

This doctoral research implements a special type of a mixed methods research approach that extends the advantages of conventional mixed methods research design in the study of healthcare geographies. As noted before, whereas conventional mixed methods research designs are concerned with integrating standard quantitative methods (i.e. statistics) with qualitative data types and methods (Tashakkori and Teddlie, 2010), this study integrates a corpus of sophisticated spatial analytics and statistics with qualitative methods. Therefore, it is a more powerful (and superior) type of explanatory sequential mixed methods design because of its explicit geographical relevance and spatial precision (Atkinson and Martin, 2000, p. 2; Kikuchi, 2010; Nelson, 2012, p. 5). By combining GIS and qualitative methods, critical human geographers are able to subvert the limitations and critiques of GIS while simultaneously taking advantage of its immense representational and analytical power (Pickles, 1995; Cope and Elwood, 2009, pp. 16,25; Aitken and Kwan, 2010; Johnston and Sidaway, 2016b, p. 159).

Despite the (ontological, epistemological and methodological) debates and challenges associated with combining GIS and qualitative methods (Cope and Elwood, 2009), the complementarity of these methodologies is now widely accepted (Elwood, 2010; Winchester and Rofe, 2010; Rosenberg, 2016). With this type of research design, patterns that may be helpful in investigating broader structural mechanisms could be revealed by quantitative analysis of survey data. At the same time, covert meanings, relationships and interactions which may be undiscernible from quantitative and spatial analysis could be discovered by qualitative analysis. In other words, the social and spatial context for performing more in-depth qualitative research can be provided by quantitative (and GIS) methods, or alternatively, the need for quantitative research can be informed by qualitative research. Diverse and creative GIS-informed mixed methods research designs are therefore encouraged and increasingly being implemented (Kearns and Collins, 2010; Gatrell and Elliott, 2015a; Rosenberg, 2016), such as Fielding and Fielding (2015) and Lohmann (2016).

Against this background, this mixed methods study was conducted sequentially in two phases in accordance with standard explanatory sequential mixed methods design. First, quantitative/spatial data were collected (from secondary sources) and analyzed in order to inform the research design of the second phase. Second, qualitative data were collected (from primary sources) and analyzed. This informs the logical organization of the remainder of this methodology chapter and the empirical chapters of this thesis, as diagrammatically depicted in Figure 3-1. The next section outlines the various data types and sources required to meet the objectives of this research project, after which the methods of spatial/quantitative data analysis are discussed.

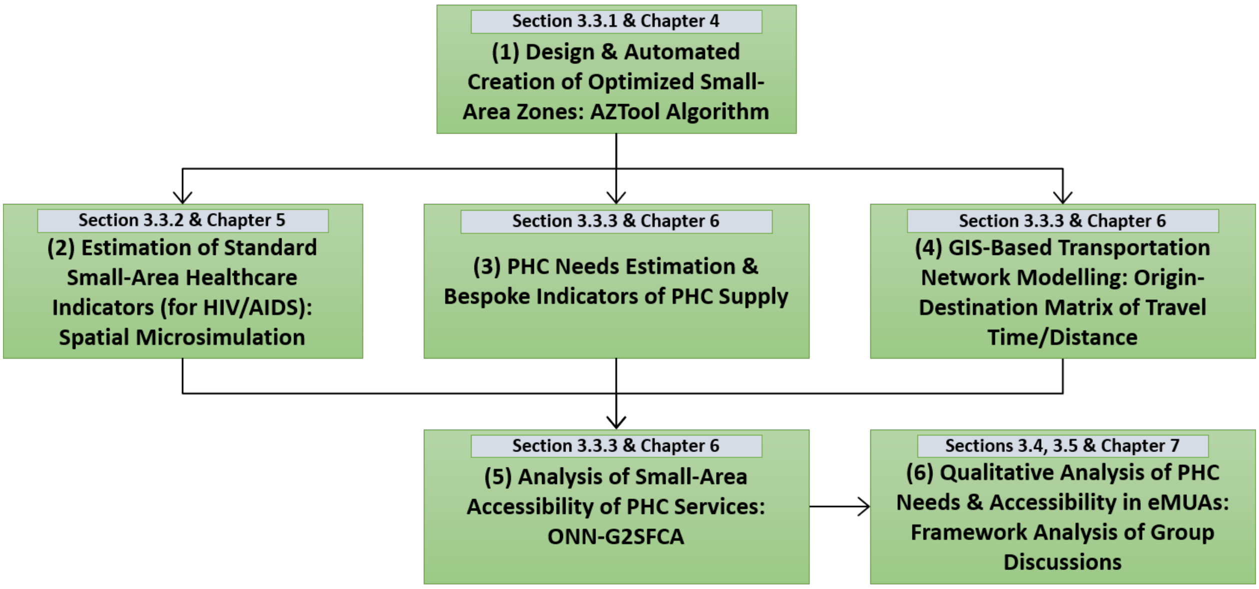

Figure 3-1 Overview of methodology workflow with related sections and empirical chapters

3.2 Data Types and Sources: Secondary

This research uses both primary and secondary data types. The primary data type is qualitative data which were collected from the field through focus group discussions. The secondary data types are quantitative and spatial data, which were downloaded from online data repositories. The remainder of this section summarizes the secondary data types and sources, while the primary data types and sources are discussed in Section 3.4.

In Table 3-1 is a summary of the quantitative data types and sources relevant to this study. These data types are categorized into the following groups:

- Administrative boundaries and settlements' maps;
- Population count and attributes;
- Healthcare facilities and services;
- Road network and transportation infrastructure.

Secondary datasets on administrative boundaries and population attributes are used for the automated creation of optimized small-area geographies (called pseudo-wards or synthetic wards) for the study area. This is a foundational analytical step without which it is impossible to meet the other objectives of this study. Further details on this are provided in Section 3.3.1 below (i.e. the first research objective). The derived pseudo-wards and data on population attributes are used for the small-area estimation of standard multivariate health-related indicators, especially HIV/AIDS indicators and number of sexually active people in the study area (i.e. the second research objective). This process is detailed in Section 3.3.2. The foregoing data (i.e. healthcare needs/demand) plus transportation infrastructure data and health facilities/services data are inputs for analyzing the small-area spatial accessibility of essential healthcare services in the study area (i.e. the third research objective). Specifically, the transportation network data is used in calculating the travel distance and/or time between the various demand and supply points of healthcare in the study area. Further details on these procedures are provided in Section 3.3.3.

If social or political groups are prominent and easy to understand, group-based measures of variation are often significant and worth considering (Foster *et al.*, 2013). Therefore, in addition to revealing small-area spatial variations in the accessibility of primary healthcare services in the study area, a disaggregation of accessibility according to relevant socio-cultural categories is also performed as part of the second and third objectives. This also entails disaggregating resulting spatial accessibility indices according to LGAs and senatorial districts in order to increase their contextual meaningfulness. This move from an overall measure of accessibility to a group-based accessibility measure helps to reveal potential structural discriminations according to relevant socio-demographic markers. Lastly, places of extremely poor healthcare accessibility are identified as the focus of primary field data collection using group discussions. This is the subject for discussion in Sections 3.4 and 3.5, which is instrumental to meeting the fourth objective of this research project.

Table 3-1 A tabular summary of relevant secondary quantitative data types and sources.

Data Types	Brief Description	Data Source
Administrative Boundaries and Settlements' Mapping		
Spatial Administrative Boundary Files	Vector Files (polygons and points) of various administrative and settlement boundaries.	Humanitarian Data Exchange (HDX) website (https://data.humdata.org/dataset/nga-administrative-boundaries) Vaccination Tracking System (VTS) Website http://vts.eocng.org/geometry_export/# OpenStreetMap (OSM) website, through http://download.geofabrik.de/africa/nigeria
Population Count and Attributes		
WorldPop Gridded Population Estimates	Simple gridded population estimates of the general population at a scale of 100m and selected health-relevant attributes (at a spatial scale of 1km)	WorldPop Project Website http://www.worldpop.org.uk/
Multiple Indicator Cluster Survey (MICS) Microdata, 2016/2017	This data provides several variables on population attributes relevant to computing the MICS, MDG and SDG indicators. It has a national coverage and contains eight modules, providing demographic and socioeconomic data on individuals and households. Data on health behaviour, birth history and healthcare utilization are also provided.	The UNICEF data repository: http://mics.unicef.org/surveys
Healthcare Facilities and Services		
Nigeria Baseline Health Facility Data	A national georeferenced inventory of all healthcare facilities and their basic attributes	Nigeria MDG Information Systems (NMIS) Website http://nmis.mdgs.gov.ng, or https://redivis.com/CWP/datasets/1449/tables

Data Types	Brief Description	Data Source
		or https://africaopendata.org/dataset/nigeria-nmis-health-facility-data-2014 or https://energydata.info/dataset?
Road Network and Transportation Infrastructure		
Nigeria comprehensive road network dataset	Geometric data (as lines) of all kinds of roads from motorways to gravel tracks as well as cycle ways, footpaths, and other road types. This includes other transportation infrastructure (like bus stops, taxi ranks, railway station, airports etc), railways, water ways, building outlines, land use/cover etc.	The Humanitarian Data Exchange website (HDX) https://data.humdata.org/dataset/nigeria-road-network-main-roads, and https://data.humdata.org/dataset/nigeria-roads-data-from-osm. OpenStreetMap (OSM) website, through http://download.geofabrik.de/africa/nigeria

3.3 Methods of Spatial Data Analysis

This section considers the various methods by which the spatial and quantitative data of this study can be analyzed, including their rationales and critiques. This is the basis for selecting and implementing methods for meeting the first to third objectives of this study, with their results presented and discussed in chapters four (4) to six (6) respectively. The study area lacks appropriate zoning system with which to analyze small-area spatial accessibility of primary healthcare services as well as identify localities of extremely poor accessibility for targeted follow-on qualitative analysis. This section therefore begins with a discussion of methods for the automated creation of optimized small-area geographies. The resulting small-area zones, which are otherwise called pseudo-wards or synthetic wards, is a foundational analytical step for meeting further research objectives, as illustrated in Figure 3-1.

3.3.1 Creating Optimized Small-Area Analytical Zones: Automated Zone Designs

3.3.1.1 Background to Automated Zone Designs

In order to develop concrete measures of social organization and comprehensively explain their differences and similarities in geographic space, it is important to examine the spatial boundaries and organization of relevant social units (Irwin, 2007, p. 119). Such in-depth interrogation of the zoning systems used in analyzing socio-spatial variations is invaluable in enhancing our fundamental understanding of space, place and society. Many LMICs countries, including Nigeria, lack reliable maps of their extant zoning architecture, especially of their smallest statistical data aggregation units. In these places, only gazetteers of these small-area zones are available. Furthermore, existing zoning boundaries in many of these places are arbitrary demarcations and/or are too coarse for revealing meaningful spatial variations in many phenomena of geographical interest. Being unoptimized for robust and reliable spatial analysis of human-social phenomena, these arbitrary and/or suboptimal zoning systems are therefore very unsuitable for the socio-spatial analyses of healthcare services (Irwin, 2007; Sabel *et al.*, 2013; Zhao and Exeter, 2016). Despite the well-established issues with zoning systems (Zhao and Exeter, 2016), "it is surprising that only few authors consider the districting problem independently from a practical background" (Sabel *et al.*, 2013, p. 2; Kalcsics, 2015, p. 596). Regionalization, the process of constructing regions, is the classical geographical methodology for addressing this issue (Berry, 1964; Cliff *et al.*, 1975; Openshaw, 1977). A 'region' is a relatively homogeneous areal unit defined by a set of criteria (Johnston, 1970).

Depending on the application context, the notion of regionalization is invoked with various names, such as (re)districting, zone design, zonation, sector design, territory design, or territory alignment (Duque *et al.*, 2012; Kalcsics, 2015). In geography, regionalization has been an important and active research area since the earliest works (Berry, 1961; Spence, 1968; Monmonier, 1972; Goodchild, 1979; Haining *et al.*, 1994; Openshaw, 1996; Guo, 2008; Sabel *et al.*, 2013; Zhao and Exeter, 2016). Even though the objectives of a given regionalization application may vary depending on which nomenclature is used (or the disciplinary background), regionalization generally refers to the process of demarcating boundaries for a specific purpose (Shortt, 2009; Zhao and Exeter, 2016). '(Re)districting' is commonly used in the context of political or administrative regionalization while 'zone design' is popular in spatial analysis contexts. More specifically, districting or zone design is the grouping of small geographic areas (called Basic Units (BUs) or Building Block Areas (BBAs)) into larger contiguous geographic clusters (called districts or tracks or zones or territories) that are acceptable and/or appropriate according to relevant planning/application criteria (Altman and McDonald, 2011; Guo and Jin, 2011; Guo and Wang, 2011; Kalcsics, 2015; Zhao and Exeter, 2016). This study is concerned with the more specific term, 'zone design', which is a more appropriate nomenclature for the analytical activity performed in this project (especially the first research objective). While general regionalization may not require the use of BBAs, this is necessary in many zone design problems that require some form of optimizations. Despite its immense importance, the use of BBAs for the automated design of optimized zoning systems is one of the most complex and challenging spatial optimization problems (Amrhein, 1995; Coombes, 2000; Guo and Jin, 2011; Zhao and Exeter, 2016).

Automated zone design is concerned with the use of computer software to create bespoke regions that are optimized for given applications. A zoning system refers to the output of an (automated) zone design operation, comprising an array of unitary zones. Two crucial applications of automated regionalization are political districting and sales/market territory or service area design (Salazar-Aguilar *et al.*, 2011). Other relevant application areas are outlined in Table 3-2. In this research project, automated zone design is used to develop an optimized small-area zoning system that are appropriate for use in further spatial analysis of this study. In other words, synthetic analytical small-area zones (otherwise called pseudo-zones) are developed from this analytical step as discussed further in Chapter 4.

Table 3-2 Some application areas of automated zone design

Application Areas	**Relevant Studies**
Political districting	(Hess *et al.*, 1965; Garfinkel and Nemhauser, 1970; Helbig *et al.*, 1972; Fleischmann and Paraschis, 1988; Hojati, 1996; Mehrotra *et al.*, 1998; Bozkaya *et al.*, 2003; Ricca *et al.*, 2008; Shirabe, 2009)
Sales/market territory or service area design	(Hess and Samuels, 1971; Marlin, 1981; Zoltners and Sinha, 1983; Bergey *et al.*, 2003; Blais *et al.*, 2003; Zoltners and Sinha, 2005; Tiede and Strobl, 2006; Ríos-Mercado and Fernández, 2009)
Optimized small-area zoning system for census data collection and spatial analysis	(Openshaw, 1996; Cockings and Martin, 2005; Shortt *et al.*, 2005; Ralphs and Ang, 2009; Cockings *et al.*, 2011; Guo and Wang, 2011; Sabel *et al.*, 2013; Mu *et al.*, 2015; Mokhele *et al.*, 2016; Zhao and Exeter, 2016)
Design of territories for social facilities/services like schools, police stations, waste collection or emergency services	(Hanafi *et al.*, 1999; D'Amico *et al.*, 2002; Caro *et al.*, 2004; Alsalloum and Rand, 2006; Gendreau *et al.*, 2006; Masouleh, 2006; Perrier *et al.*, 2006; Sorensen and Church, 2010)
Land allocation/apportionment and conservation planning	(Cova and Church, 2000; Aerts and Heuvelink, 2002; Williams, 2002; Church *et al.*, 2003)

Despite several application domains of (automated) zone designs, it is noteworthy that not all of these are intended to meet the same goals. For instance, while many applications in geography (such as this study) and related disciplines are interested in using automated zone designs to minimize or bypass the downsides of zone-based spatial analysis discussed in Section 3.3.1.2, other application domains pursue other goals. The automated zone design of this study is concerned with creating optimized small-area zoning systems for geographic data presentation/mapping, especially for the spatial analysis of healthcare accessibility and their inherent disparities. Another fundamental premise for this activity is that without optimized small-area zoning systems, small-area analysis of spatial accessibility, as well as prescribed optimal healthcare coverage scenarios from location-allocation models, are inherently sub-optimal to the extent that utilized data aggregation zones are sub-optimal. This is an aspect not well considered in most other studies on this subject; therefore, this is an important advance. The potential effects and general problems of sub-optimal zoning systems on the analysis of healthcare accessibility are discussed further in Section 3.3.1.2 below and illustrated in Section 3.3.1.3.

3.3.1.2 General Problems with Extant Zoning Systems

There are many theoretical and pragmatic reasons for being mindful of the zonation architecture in every context (Guo and Jin, 2011). A basic problem in socio-spatial analysis is the small population (or numbers) problem (Cromley and McLafferty, 2012, p. 153; Sabel *et al.*, 2013, p. 3; Wang, 2014b, p. 194). This is popular in the analysis of rare events (like in health and crime studies), whereby zones with small populations exhibit higher degrees of variability in event/incident rates and are less reliable than rates calculated for more highly populated areas. The design and creation of optimized zoning systems using automated zone design methods is an invaluable method for overcoming the small population/number problem in spatial analysis (Wang, 2014b, p. 196). Furthermore, arbitrarily constructed zoning systems often significantly misrepresent inherent socio-spatial variations (Irwin, 2007; Cromley and McLafferty, 2012). This is well explained by – the Modifiable Area Unit Problem (MAUP) (Openshaw, 1984; Wong, 2009a, 2009b; Flowerdew, 2011), 'gerrymandering' (Lewyn, 1993; Monmonier, 2018), aggregation bias or ecological fallacy (Fotheringham and Wong, 1991; Amrhein and Flowerdew, 1992; Paelinck, 2000) and the Uncertain Geographic Context Problem (UGCoP) (Kwan, 2012; Cabrera-Barona *et al.*, 2018). MAUP explains the impact of the location and configuration of zoning systems on the findings of analyses, while 'gerrymandering' is a political manifestation of the MAUP whereby political/administrative boundaries are deliberately manipulated (or shaped/configured) in favour of a political party or to discriminate against social or ethnic minorities. MAUP suggests that the findings from spatial analysis holds true only for the given configuration and scale of zoning system used, research conclusions may therefore not be generalizable (Johnston and Sidaway, 2016a, p. 174). Associated with the MAUP is the problem of 'ecological fallacy'[29] which results from ascribing analytical inferences obtained from aggregate/zone data to true individuals or point locations within the zones (Tranmer and Steel, 1998; Johnston and Pattie, 2001; O'Sullivan and Unwin, 2010, p. 39; Longley *et al.*, 2015, p. 122; Johnston and Sidaway, 2016a, p. 152). That different delineations of contextual zones result in different research outcomes is also explained by the UGCoP, which further foregrounds the lack of knowledge about the nature of uncertainty in the resultant deviations from the substantive or relevant geographical

[29] One way of minimizing the problem of ecological fallacy is to create bespoke analytical zoning systems with high degree of intra-zonal homogeneity, which among other things is discussed in the same section 3.3.1 and actualized in Chapter 4. Other methods include Spatial Microsimulation (which is the focus of Chapter 5) and entropy-maximization (Johnston and Sidaway, 2015, p. 152; Johnston and Pattie, 2003).

context. The use of extant census and administrative boundaries to report small-area or 'neighbourhood statistics' may therefore produce misleading or inaccurate results because they are not designed for investigating such data (Openshaw, 1977; Shortt, 2009; Zhao and Exeter, 2016). However, in many instances, practical and administrative reasons (like data availability) necessitate the use of extant readily-available zones, despite their inappropriateness (Wakefield, 2004; Burden and Steel, 2016b).

Optimized small-area geographies created by automated zone design methods are also appropriate need aggregation zones for the optimal spatial reconfiguration of healthcare services' coverage, by serving to minimize aggregation-induced errors. Even though the aggregation of need provides the benefit of reducing the complexity of routing and location problems, it has some important implications for location modelling (Sadigh and Fallah, 2009; Cromley and McLafferty, 2012, p. 362). In location modelling, aggregation zones result in under- or over-estimation of the actual travel time or distance for individuals (Kwan, 1998, 1999), thereby serving as a source of error. This implies that a modelled optimal healthcare coverage pattern based on aggregated need zones may be suboptimal at the individual-level or smaller areal zones (Daskin *et al.*, 1989; Current and Schilling, 1990; Francis *et al.*, 2009). This error is minimized by using automated zone design approaches to create optimized aggregation zones.

In England and Wales, new census output geographies for both the 2001 and 2011 population censuses were designed by Prof Dave Martin and his team (at University of Southampton) using automated zone design algorithms (Martin, 1997, 1998a, 1998a, 2001, 2003; Cockings *et al.*, 2011). Their works also consider the applications of automated zone design approaches in health studies (Martin *et al.*, 1998, 2002; Cockings and Martin, 2005). More recently, the work of authors like Sabel *et al.* (2013) corresponds with the motivation and rationale of Martin's work but focuses on the use of automatized zone design for analyzing the neighbourhood relationship between health and the social and physical environment. In this regard, most existing studies on automated regionalization have attempted to use extant fine geographic zones like Enumeration Areas (EAs) as building blocks to construct larger purpose-specific zoning systems according to relevant design criteria (Unwin, 1996; Sundquist *et al.*, 1999; Elliott *et al.*, 2001; Tatalovich *et al.*, 2006; Jones *et al.*, 2010). The implication is that the boundaries of the resulting bespoke zoning systems are determined by the boundaries of the extant building blocks from which they were aggregated. One problem is that the extant building blocks (BBAs) used often have inherent limitations such as variations in population size, geographical area, or shape and social composition, which may be transferred to the resulting larger bespoke zoning system (Cockings and Martin, 2005). The use of extant geographic zones as building blocks also limits the spatial granularity of the resulting bespoke zoning system, being that they cannot be as small as (or smaller than) the extant building blocks from which they were created. To overcome this problem, Sabel *et al.* (2013) use individual-level building data, represented as grid cells that serve as the building block areas to design neighbourhoods (i.e. synthetic zones) from scratch, bottom-up. In a similar vein, the current thesis features the innovative exploitation of gridded demographic data from the WorldPop Project in developing BBAs and subsequent optimized Small-Area analytical zones for this research project.

This section therefore develops on the foregoing works, especially that of Sabel *et al.* (2013). For instance, while Sabel *et al.* (*ibid*) use square tessellations as building block areas, this study uses hexagonal tessellations as the building block areas (BBAs), which Sabel *et al.* (*ibid)* suggest would yield more compact (or congruent) synthetic zones and boundaries. Furthermore, Sabel *et al.*'s (*ibid)* work does not consider the constraint of pre-existing zone boundaries. They are not interested in exploring variations in the characteristics of extant zoning systems based on the larger zones in which they are nested. Being restricted to the inhabited places of their study area, the derived zoning system from their study is not space-filling. Hence, it will be of limited applicability in contexts like the current study area where rapid settlement expansions are likely to overshoot the precincts of currently inhabited space at the time of a study. As will be explicated in Chapter 4, this study not only considers the spatial constraints of pre-existing zones but also analyzes variations in the extant and synthetic zoning systems based on the higher-level geographies of the study area (i.e. the LGAs and the senatorial districts) in which they are nested.

Furthermore, Briggs *et al.* (2007) outline some motivations or rationales for using optimal zoning systems in health geography, as follows:

- To provide a uniform basis for mapping, both to aid visual representation and interpretation of the data and also to facilitate analysis of spatial patterns;
- To have a zone system that is sufficiently fine to reflect local variations in exposures and rates of disease, especially in urban areas where such gradients may be steep;

- To achieve reasonably large and consistent denominator populations in all zones, to avoid the so-called small number problem, which can lead to highly unstable estimates of risk and large variations in uncertainty between zones; and
- To minimize the need for spatial transformation of data between different spatial units, since this invariably involves some degree of approximation and is thus a further source of error.

These imply that the use of optimized small-area analytical zones in this thesis is an important advance over other similar works, as discussed further in Section 3.3.1.3 below.

3.3.1.3 Optimization Criteria for Small-Area Zoning Systems

There are well-established general and application-specific criteria or guidelines for designing optimized zoning systems (Martin, 1997, 1998a, 1998b; Alvanides, 2000; Cockings and Martin, 2005; Daras, 2006; Briggs *et al.*, 2007; Flowerdew *et al.*, 2008; Ralphs and Ang, 2009; Kalcsics, 2015; Zhao and Exeter, 2016). Thus, this section focuses on the standard criteria or guidelines for designing optimized small-area zoning systems for equity-sensitive spatial analytics. Even though the criteria discussed here are with reference to the aggregation of healthcare needs/demand as well as analyzing the spatial accessibility of healthcare services and its inequalities, these guidelines are of general relevance to many other application areas in spatial analysis. In contrast, however, Political Districting Problems (PDP) require additional (often contentious) zone design guidelines which are well-documented elsewhere (Williams Jr, 1995; Puppe and Tasnádi, 2008; Bozkaya *et al.*, 2011; Webster, 2013; Kalcsics, 2015; Goderbauer and Winandy, 2018).

A. Standardized Zonal Population

It is important for zones to have a standard population size that is balanced (Duque *et al.*, 2012, p. 3; Kalcsics, 2015, p. 599), not least because a zoning system with roughly equal population size tends to be both egalitarian and more efficient than zoning systems comprising greatly varying population sizes (Flowerdew *et al.*, 2008, p. 4). In terms of standardized population size, an ideal zoning system should have the following characteristics: (1) Minimum population size above a threshold, (2) Mean population size about the same as the area unit geography (i.e. small population standard deviations), (3) A narrow distribution of population sizes (i.e. small population range) (Martin, 1998a, 1998b; Ralphs and Ang, 2009, p. 42). By meeting relevant service threshold requirements, there is the assurance that zones would possess a high capacity to utilize a social facility (like a hospital or school) as well as have an equitable workload (Blais *et al.*, 2003; Benzarti *et al.*, 2013; Kalcsics, 2015). Capacity limitations would also be met, such that a small hospital is not expected to serve a large demand area. These principles of standardized population are therefore operationalized in this study in Chapter 4, Section 4.2.2.

B. Zone Shape or Compactness

Compactness, otherwise known as shape index, is a numerical measure of the degree to which a shape is circular, because a circle is the most compact shape (Gillman, 2002; Montero and Bribiesca; Li *et al.*, 2013). This is an essential optimization criterion of analytical/functional zones for the analysis of spatial accessibility because, in addition to spatial contiguity, shape compactness helps to optimize the accessibility and connectedness of a zoning system (Cliff *et al.*, 1975, p. 17; Kalcsics, 2015, p. 599; Zhao and Exeter, 2016, p. 15). Furthermore, not only do compact shapes facilitate the assessment and interpretation of spatial patterns owing to their aesthetic appeal (Angel *et al.*, 2010; Li *et al.*, 2013, p. 1228), they are likely to be internally homogeneous, sharing similar (socioeconomic) attributes and properties – the first law of Geography (Tobler, 1970; Horn, 1995). However, the ability to achieve compact zones in an optimized zoning system is dependent on the degree of compactness of BBAs and/or their social geography (Flowerdew *et al.*, 2007, 2008; Zhao and Exeter, 2016).

In this study, shape compactness is measured as the square of perimeter divided by area, denoted by the metric P2A (Cockings and Martin, 2005; Flowerdew *et al.*, 2007; Haynes *et al.*, 2007; Sabel *et al.*, 2013). Mathematically,

$$P2A = \sum q_k^2 / A_k$$

Where q_k is the perimeter of zone k and A_k is its area.

Shape compactness decreases as P2A score increases, with the most compact shape, a circle, having the minimum (and best) achievable P2A score of one (Ralphs and Ang, 2009; Mokhele *et al.*, 2016, p. 15). This criterion is implemented in chapter 4, Section 4.2.2.

C. Internal Homogeneity of Zones

It is essential that zones are internally homogeneous in terms of their socioeconomic and demographic composition as a way of endogenously recognizing the social zones/neighbourhoods in a study area (Martin, 2000, p. 110). With more intra-zonal homogeneity, the problem of ecological fallacy is minimized since individuals in a homogeneous zone are likely to resemble the overall social attributes of their originating zones (Shortt, 2009; Longley *et al.*, 2015, p. 122; Zhao and Exeter, 2016). Consequently, less inferential bias as well as more analytical precision is likely to result from the use of zoning systems with very homogeneous zones (Flowerdew *et al.*, 2008; Burden and Steel, 2016b). It is however sometimes unclear which variables are best in assessing zoning homogeneity with regards to understanding contextual and compositional effects on health.

In Section 4.2.2, intra-zonal homogeneity is measured using select health-related socio-economic variables for which datasets were available, specifically the proportion of: (1) poor people, living below £1.25/day, (2) women of age 15 – 45 years who use modern contraceptive methods, (3) people of age 15 – 49 years who are literate, and (4) stunting in children of less than 5 years old. Intra-zonal homogeneity is calculated as Intra-Area Correlation (IAC) metric (Tranmer and Steel, 1998; Martin *et al.*, 2001; Sabel *et al.*, 2013). Mathematically,

$$\mathrm{IAC} = \frac{1}{k-1}\sum_{k=1}^{k}(1-p_k)\delta_k$$

With d_k being the contribution of category k (i.e. the four proportional social attributes considered) to the IAC,

$$\delta_k = \left[\frac{1}{M-1}\sum_{g=1}^{M}N_g(P_{kg}-P_k)^2\Big/(\bar{N}^*-1)P_k(1-P_k)\right]-\frac{1}{\bar{N}^*-1},$$

Where:

M is number of areal units,

N* is the mean population size of the M areal units, with an adjustment to take into account variation in the population size of the areal units;

N_g is the population size of areal unit g,

P_k is the overall proportion of the population in category k,

P_{kg} is the proportion in category k in areal unit g.

IAC values range from 0 to 1, with higher values connoting more intra-zonal homogeneity (Steel and Tranmer, 2011; Cockings *et al.*, 2013). Values of 0.05 and above are considered to represent a reasonable level of intra-zonal homogeneity (Martin *et al.*, 2001, p. 7). In this study, a good level of intra-zonal population homogeneity implies that primary healthcare facilities are adaptable to the peculiar demographic attributes (and by extension the healthcare needs) of their services' area, thereby making provided services more attuned and acceptable to the local population. For instance, a homogeneous population zone is likely to experience similar types of health conditions (such as aging-related ailments or poverty-related ailments like stunting or malnutrition), in which a local healthcare provider may specialize.

D. Contiguity of Zones

Zones are said to be contiguous if all the Building Block Areas (BBAs) that form a zone are interconnected by sharing at least one edge, thereby making it is possible to travel within the basic units or BBAs of a district without leaving the same district. Contiguity ensures the connectivity of BBAs within a zone, such that only adjoining parts constitute a zone (with the exception of archipelagos and other similar disjointed natural features) (Coombes, 2000). Contiguous non-overlapping zones is an important zone design criteria because, together with compactness, it helps to reduce unproductive travel time as well as for clearly defining geographic areas of responsibility (or administration) (Flowerdew *et al.*, 2008, p. 4; Butsch *et al.*, 2014; Kalcsics, 2015, p. 601; Zhao and Exeter, 2016, p. 15). Along with shape compactness, contiguity also helps to mitigate gerrymandering in the case of political districting problems (Kalcsics, 2015, p. 606). Furthermore, shape contiguity and compactness helps to prevent doughnut shapes in zoning systems, i.e. a zone that entirely surrounds another zone (Flowerdew *et al.*, 2008).

Contiguity is however difficult to achieve in study areas that contain islands or natural demarcations like large rivers. Optimized zoning systems are typically expected to respect natural (or impermeable artificial) boundaries by not extending over such features. Indeed, this is the case with the study area, Kogi State, in which the two major rivers in Nigeria (Niger and Benue) constitute a major natural barrier over which no optimized synthetic ward is designed to cross (see Figure 6-1). This is one of the hard criteria implemented in Section 4.2.2. Contiguity problems arising from Islands can be resolved by considering existing islands as being contiguous with adjacent mainland or port BBAs.

E. Number of Zones

If an optimized zoning system is designed with an intention for comparison with extant zoning systems (such as ward geographies), the desired number of zones ought to be the same or close to that of the existing zones (Flowerdew *et al.*, 2008). This is relevant for comparing the extant zoning system of the study area with the optimized synthetic variant derived from the automated zone design operations in Sections 4.3.1 and 4.3.2. However, there are many practical instances whereby at the outset of a study, the optimal number of zones for a zoning system is unknown (Duque *et al.*, 2012). This is related to the scale problem (of the MAUP) of which various methods for determining the optimal number of application-specific zones abound (Milligan and Cooper, 1985; Hardy, 1994; Gordon, 1999). Thus, the choice of an appropriate method can be complicated. Nevertheless, experience has shown that whenever a researcher performs automated zone design (with a view to developing an optimal zoning system for a study), s/he may have an idea of a set of zone design criteria that should be fulfilled in order for the resulting analytical zones to be appropriate for the empirical application at hand (Duque *et al.*, 2012, p. 4). These known design criteria therefore serve as a basis for endogenizing an optimal number of zones for the zoning system of the given application, with the aid of an appropriate zone design algorithm. This is the basis for determining the optimal number of zones for the optimized small-area zoning system derived for this research project in Chapter 4 (Section 4.3.3).

A major challenge in the automated design of analytic zoning systems is the determination of what measures/variables to adopt for each of the foregoing criterion. Associated with this is how to balance multiple criteria in a given zone design project. These concerns are effectively handled by various automated zone design algorithms/packages, such as the AZTool package employed in the current study. AZTool is chosen because it is amongst the most robust options that is relatively user friendly; thus, it has also received extensive attention in relevant literature (Martin, 1997, 1998a, 1998b, 2000, 2001, 2014; Cockings and Martin, 2005; Cockings *et al.*, 2011, 2013; Cockings, 2013; Sabel *et al.*, 2013; Mokhele *et al.*, 2016). Ralphs and Ang (2009) and Cockings (2013) provide excellent overviews of the use of the AZTool, whereas other specialist software tools for implementing automated zone designs are highlighted in Appendix A.3.1. The next section briefly considers some critiques of these methods.

3.3.1.4 Some Critiques of Automated Small-Area Zone Creation

Even though many optimization methods/algorithms have been developed for automated zone designs, there is no guarantee of finding the 'best' solution in large (real-life) applications (Guo and Jin, 2011). In computer science (Fortnow and Homer, 2003; Arora and Barak, 2009; Homer and Selman, 2014), automated zone design problems belong to a group of complex and intensive computational problems known as Nondeterministic Polynomial-time Complete (NP-Complete) problems (Garey and Johnson, 1979; Altman, 1997; Puppe and Tasnádi, 2008). The solution of computational problems belonging to the NP-Complete complexity category can be verified quickly, but there is no known way to find an exact solution rapidly. They are therefore considered intractable computational problems, because even though they can be solved in theory, any exact solution takes too much computing resources (especially computer processing time and microprocessor power) to be useful in practice. In order to overcome this problem, automated zone design problems involving large study areas such as the current study are implemented using heuristics that are able to produce near-accurate approximate results efficiently. This is the approach implemented in this study by the AZTool algorithm, as discussed in Chapter 4 (Section 4.2).

Spatial optimization methods generally possess two limitations (Guo and Wang, 2011). First, they are all computationally intensive. Second, some methods such as the AZTool used in this thesis are based on heuristics and random search algorithms, which produce a different result per run. They are therefore not amenable to exact replication and verification. Furthermore, with a few recent exceptions (like the AZTool, REDCAP, MLR, iRedistrict), many automated regionalization tools are not adept at ensuring that the population of newly formed regions are above a given threshold (i.e. the small population problem) (Wang, 2014b; Mu *et al.*, 2015). Aside from the various inefficiencies and limitations of specific automated zone design algorithms/methods reported in the literature (Guo and Jin, 2011; Guo and Wang, 2011; Duque *et al.*, 2012; Zhao and Exeter, 2016), no theoretical justification is given for these optimization algorithms; therefore, they may not yield a representative sample of the zone design options for a target population (Fifield *et al.*, 2018). Being largely based on an abstract conceptualization of the zone design problem, most techniques completely neglect the inherent geographical nature of the problem (Kalcsics *et al.*, 2009, p. 3).

Despite these limitations and/or critiques, automated zone design methods generally produce small-area zoning systems that are much better than the unoptimized small-area zones that result from arbitrarily/manual demarcation of regions. Therefore, automated zone design is an invaluable spatial analytical method, especially in LMICs like Nigeria, wherein the extant zoning system tends to be very problematic. In Chapter 4, the benefits of creating an optimized small-area zoning system for the study area are underlined in contrast to using the extant arbitrarily defined zones. The next section turns to the small-area estimation of relevant healthcare attributes, with a focus on spatial microsimulation.

3.3.2 Estimating Standard Multivariate Healthcare Attributes for Small-Area Zones: Spatial Microsimulation

Because the estimation of small-area healthcare needs is an indispensable step in meeting further objectives of this study, this section is concerned with the second objective of this doctoral research project: estimate and map the small-area needs of general and specific primary healthcare services. This constitutes a Small-Area Estimation (SAE) problem. Generally, "the term small-area typically refers to a small geographic area or a spatial population unit for which reliable statistics of interest cannot be produced due to certain limitations of the available data." (Rahman and Harding, 2017, p. 12). A small-area can be – a geographic region such as a suburb, a central business district, a ward and a Statistical Local Area (SLA); or a socio-demographic domain such as a '*sex* x *age* x *education* x *income'* unit; or a demographic subdomain within a geographic unit. In this research project, a small-area is synonymous with a SLA and operationally refers to the bespoke optimized small-area analytical zones derived from the process of automated zone design discussed in Section 3.3.1 (and implemented in Chapter 4). With the automated creation of optimized small-area zones comes the problem of determining relevant population attributes for the resulting bespoke zones. In this study, aggregate demographic characteristics of people in the small-area zones are necessary for estimating small-area need (i.e. potential demand) for primary healthcare services in the study area.

There are many methods for Small-Area Estimation (SAE) which are well-explained by various authors (Rahman, 2008; Whitworth, 2013; Rao and Molina, 2015; Rahman and Harding, 2017; Whitworth *et al.*, 2017). A good overview of SAE methods is presented in Figure 3-2 after Rahman and Harding (2017). Other popular methods for estimating small-area population attributes are areal interpolation approaches (Goodchild and Lam, 1980; Goodchild *et al.*, 1993; Wu *et al.*, 2005; Zandbergen and Ignizio, 2010; Langford, 2013) like dasymetric mapping (Langford and Unwin, 1994; Eicher and Brewer, 2001; Mennis, 2003; Mennis and Hultgren, 2006; Mennis, 2009; Tapp, 2010; Cromley *et al.*, 2012) and pycnophylactic interpolation (Tobler, 1979; Langford *et al.*, 1991); as well as Bayesian estimation (Congdon, 2006, 2014) or multilevel modelling for small-area population estimation (Moon *et al.*, 2007). This research project focusses on Spatial Microsimulation Modelling (SMM) because it is the main geographical approach for SAE. In the words of Whitworth *et al.* (2017, p. 2), "[Spatial Microsimulation] approaches seek in differing ways to 'fit' the survey cases as closely as possible to the multi-dimensional characteristics of each separate small area for the set of selected key explanatory variables (termed 'small area constraints' in the literature) for which aggregate small area totals are known, in effect using the survey data to create synthetic micro-populations for each target small area in turn and then using this to pick off estimates of the outcome variable of interest".

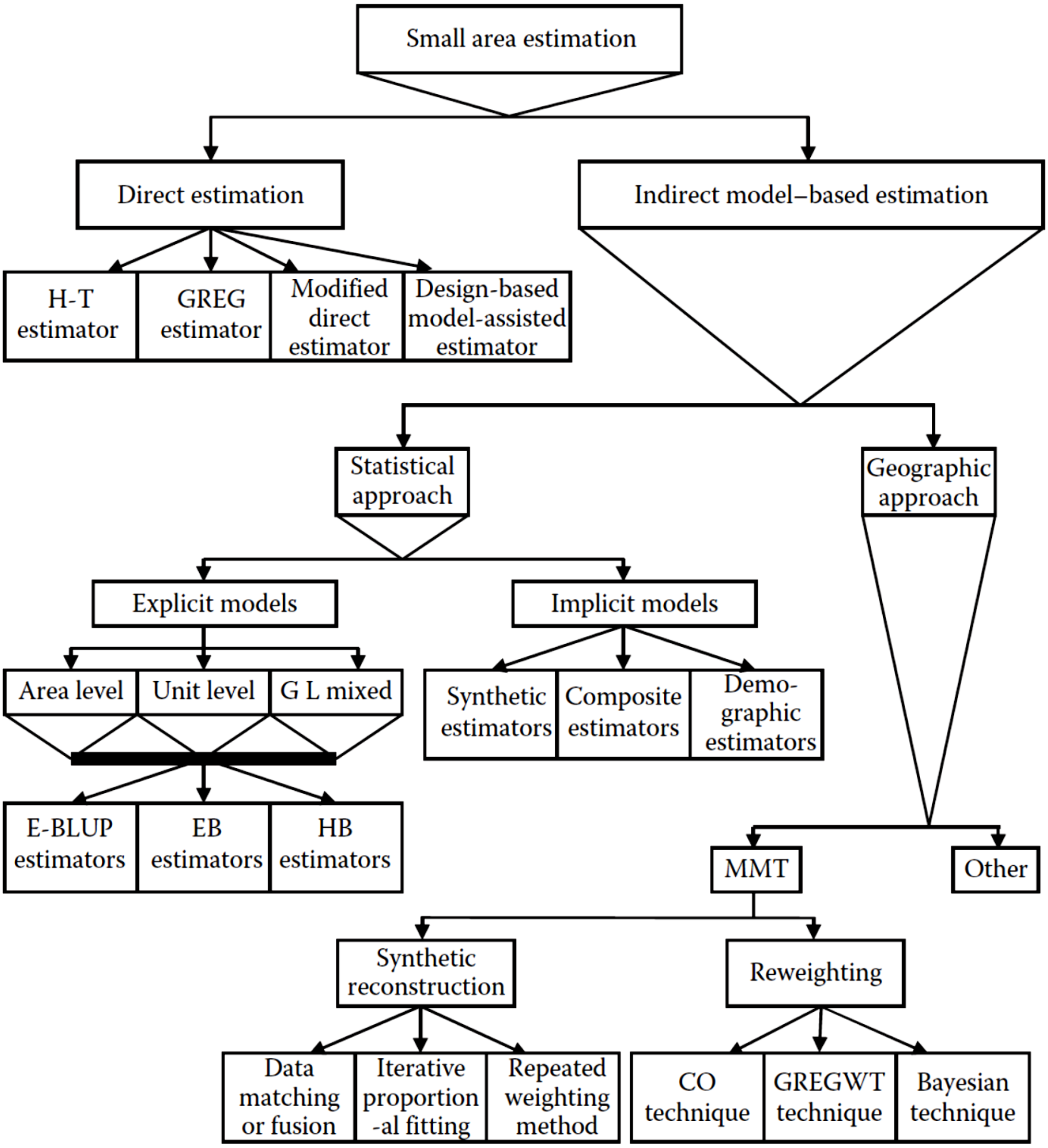

Figure 3-2 A summary of different techniques and estimators for SAE[30] (Rahman and Harding, 2017, p. 16).

[30] **Key:** H-T, Horvitz–Thompson; GREG, Generalized Regression; G L, Generalized Linear; E-BLUP, (empirical) best linear unbiased prediction; EB, empirical Bayes; HB, hierarchical Bayes; MMT, microsimulation modelling technology; CO, combinatorial optimization; GREGWT, generalized regression weighting.

The three main approaches of SMM are Iterative Proportional Fitting (IPF), Combinatorial Optimization (CO) and Generalised Regression Reweighting (GREGWT). These methods are explained extensively by many authors, including Rahman and Harding (2017), Whitworth *et al.* (2017), Tanton and Edwards (2013a) and Lovelace and Dumont (2016). The remainder of this section concentrates on the Combinatorial Optimization technique of SMM, being the choice approach of this study.

3.3.2.1 Background to Spatial Microsimulation

Many policy-relevant phenomena exhibit significant spatial variability; therefore, there has been an increasing demand for spatially detailed statistics in recent years (Tranmer *et al.*, 2005; Getis, 2008; Roux and Mair, 2010; Rosenthal, 2012). This has motivated the development of Spatial Microsimulation Models (SMM) that enable researchers to estimate attributes of individuals (for various geographic units) by combining traditional census-style aggregate statistics about an area (often a small-area) with individual-level data (i.e. microdata) from surveys in order to generate a population that contains estimated characteristics from both datasets (Ballas *et al.*, 2005). This is done with a view to simulating virtual populations whose characteristics are as close as possible to their real-world counterparts. In SMM, these aggregate statistics of individuals are called (spatial) constraints or benchmarks, while the microdata is called the population. For example, if we know the aggregate sex, education and income in an area, microsimulation would generate and allocate synthetic individuals to small-areas, such that the resulting aggregate sex, education and income will be equal to the original input small-area aggregates. In addition, SMM can be used to estimate levels of additional variables if we know there is a strong relationship between the chosen constraints and those additional variables. In this project, a major assumption is that there is a strong relationship between the selected constraints and the MICS 5 indicators being computed for small-areas. There is no attempt to verify this assumption because these variables are the only available small-area constraints for SMM in the study area, and indeed in the entire country at the time of this study. Moreover, the MICS 5 indicators are computed from multiple variables of the synthetic population; hence, there is not a single target variable in this case.

Microsimulation is “a methodology... to simulate the states and behaviours of different units — e.g. individuals, households, firms — as they evolve in a given environment – a market, a state, an institution” (Baroni and Richiardi, 2007, p. 2). Not all microsimulation models are spatial; therefore, spatial microsimulation implemented in the current study can be differentiated from aspatial microsimulation (Ballas *et al.*, 2005; Lovelace and Dumont, 2016). A microsimulation model is 'spatial' if the 'environment' (as mentioned in Baroni and Richiardi's definition) is defined in predominantly geographical terms, that is, the individuals are allocated to small parcels of land (i.e. small-areas) which affect their characteristics and inferred behaviour. It is the use of geographical domains/zones as the grouping variable (i.e. the use of spatial constraints/benchmarks) that is exclusive to spatial microsimulation and which distinguishes it from aspatial microsimulation (Lovelace and Dumont, 2016). Aspatial microsimulation typically uses aspatial constraints such as age band or the number of bedrooms in a household etc as their grouping variable.

Microsimulation models can also be static or dynamic (Heppenstall and Smith, 2014; Rahman and Harding, 2017). Static SMM constructs a synthetic population at a definite time, but do not consider changes to the population size or attributes at a future time. Its main emphasis is on fusing small-area population aggregates (i.e. the spatial constraints) with a sample survey microdata to derive a synthetic population that is rich in attribute and spatial details. On the other hand, in a dynamic microsimulation model, the characteristics of the synthesized population are modelled to change/update over time as a function of endogenous factors within the model. Thus, dynamic microsimulation models feature various degrees of interaction among the micro-population units, such as processes of birth or fertility, marriage, death, or migration. Transition probabilities (of the modelled endogenous factors) are used to age or update dynamic microsimulation models. This research project is concerned with static spatial microsimulation modelling with a view to eliciting small-area estimates of multivariate health-related attributes as well as disaggregating accessibility indices by relevant sociodemographic stratifiers.

Many recent reviews explain the development of SMMs, such as Birkin and Clarke (2011), Ballas *et al.* (2013, 2019), and Hermes and Poulsen (2012a). Detailed conceptual overviews of this method are provided by authors like Ballas *et al.* (2005), Rahman and Harding (2017), Tanton and Edwards (2013a), Lovelace and Dumont (2016), Heppenstall and Smith (2014), and Harland and Birkin (2015). SMMs are particularly useful for health studies because spatially detailed health data are rarely available (Burden and Steel, 2016). Consequently, a wide variety of health-related issues have been addressed with SMM, as shown in Table 3-3. In many of these studies, SMMs are often used to estimate the small-area need for various healthcare services as a basis for assessing service accessibility and/or optimizing the location of the target service. For example, see: Tomintz *et al.* (2008, 2013), Ballas *et al.* (2006), and Morrissey *et al.* (2013a).

Table 3-3 Examples of health-related applications of SMM

Examples of health-related applications of SMM	**Relevant Studies**
Depression or psychological distress	(Morrissey *et al.*, 2010; Riva and Smith, 2012)
Healthcare accessibility	(Morrissey *et al.*, 2013a, 2015; Tomintz *et al.*, 2013; Shulman *et al.*, 2015, 2016)
Smoking	(Tomintz *et al.*, 2008, 2016; Smith *et al.*, 2011; Hermes and Poulsen, 2012b; Denman *et al.*, 2015; Eberth *et al.*, 2018; Tomintz and Barnett, 2018)
Health inequalities	(Ballas *et al.*, 2006; Campbell and Ballas, 2016)
Obesity	(Cataife, 2014; Koh *et al.*, 2018)
Health risk assessment	(Levy *et al.*, 2014)
Health outcomes	(Markham *et al.*, 2017)
Mental illness	(Morrissey *et al.*, 2015)
Hospital demand	(Morrissey *et al.*, 2013c; Shulman *et al.*, 2015)
Alcohol consumption	(Riva and Smith, 2012)
Diabetes	(Zmölnig *et al.*, 2016)

In this research project, a static spatial microsimulation model is used to derive a synthetic micro-population of the study area, based on which adapted MICS 5 algorithms for calculating various MICS 5 Indicators are implemented to derive small-area estimates of relevant MICS 5 indicators. These efforts are geared towards unravelling social and spatial variation of primary healthcare accessibility in the study area, with a view to precisely identifying places of extremely poor accessibility to primary healthcare. Specifically, with SMM some standard small-area estimates of HIV/AIDS and sexual behaviour indicators are computed from MICS 5. Similarly, small-area estimates of number of sexually active people in the study area are also computed and mapped. In meeting the second research objective of this study, these serve as precise measures of the need and potential demand for HIV/AIDS as well as sexual and reproductive healthcare services in the study area. To this end, the assumptions of SMMs are outlined in the next sub-section, after which some of its key limitations are highlighted.

3.3.2.2 Assumptions of the Spatial Microsimulation Approach

As with most quantitative analytical methods, SMM is not without assumptions that are worth noting. These are documented by Lovelace and Dumont (2016, p. 43), as follows:

- The microdata (i.e. individual-level data) is representative of the study area;
- The target variable is dependent on the constraint variables such that their spatial and temporal interaction is relatively constant;
- The relationship between constraint variables are spatially independent (i.e. no spatial autocorrelation);
- The input datasets (i.e. the microdata and constraints) are sufficiently rich to produce the full diversity of individuals and areas in the study area.

It therefore follows that the extent to which these assumptions are met by a given dataset determines the realism of the resulting synthetic populations and the small-area estimates thereof.

3.3.2.3 Criteria for the Selection of Spatial Constraints

Appropriate spatial constraints can be selected by – the use of literature reviews (Birkin and Clarke, 2012), consultations with end-users (Chin and Harding, 2006), regression analyses (Chin and Harding, 2006; Tanton *et al.*, 2011; Harland *et al.*, 2012b) and analysis of intra-area homogeneity (like the D-Statistic) (Steel and Tranmer, 2011; Burden and Steel, 2016a). Regression analysis identifies variables that make statistically significant contributions to the explanatory power of the SMM. It also ensures that the constraints represent the distribution of the target (or outcome) variable by being significantly correlated. Analysis of intra-area homogeneity ensures that selected spatial constraints adequately emulate the diversity and spatial variation in the resulting synthetic population from a SMM (Smith *et al.*, 2009; Birkin and Clarke, 2012). This is a crucial criterion that not only distinguishes SMM from other related methods like random aggregation (Steel and Holt, 1996) and non-spatial microsimulation but also ensures that the spatial structure of a derived synthetic population is adequately accounted for at the small-area scale (Tranmer *et al.*, 2005). To sum up, a general set of principles for selecting spatial constraints for SMM are outlined as follows (Burden and Steel, 2016a, p. 572):

1. The chosen set of constraints must provide basic demographic information about individuals in the population;

2. The set of constraints must be associated with the outcome(s) of interest, to maximize information and ensure the distribution of the outcome is represented by the constraints;
3. The constraints should not be highly collinear to minimize processing time;
4. The set of constraints must reflect the spatial variation of the population;
5. The set of constraints must represent a broad range of relevant socioeconomic dimensions.

In instances where the output of a SMM is intended for multiple uses, or where constraint variables with appropriate correlations with the target variables may not be known, a variety of personal and demographic characteristics should be included as spatial constraints (Birkin and Clarke, 2011). Therefore, the PROGRESS stratifiers is a robust framework for selecting constraints since they also represent the standard dimensions for data disaggregation in equity-sensitive projects (O'Neill *et al.*, 2014; Freistein and Mahlert, 2016; United Nations Development Programme (UNDP), 2018). Even though most of the foregoing criteria tend to be fulfilled by the current study, the extent to which these criteria can be fully achieved in real-life applications remains contentious, especially in developing contexts where data limitations are serious impediments to the development of robust SMMs. Further discussions on data challenges are featured in Section 3.3.3.1. The next section discusses the SMM approach with emphasis on the Combinatorial Optimization (CO) approach implemented in this study.

3.3.2.4 The Implementation of Spatial Microsimulation Models (SMMs)

Succinct explanations of the SMM methodology and the CO approach are provided by authors such as Rahman *et al.* (2010), Hermes and Poulsen (2012a) and Harland *et al.* (2012b). These authors also compare the CO approach to the other approaches of SMM like Iterative Proportional Fitting (IPF) and Generalized Regression Weighting (GREGWT), and suggest that the CO approach performs better (Anderson, 2013; Edwards and Clarke, 2013; Tanton *et al.*, 2013; Williamson, 2013). For brevity, it suffices to show the CO process of SMM diagrammatically in Figure 3-3, while further discussions are provided in Section 5.3 in the light of its empirical implementation in the current study using the Flexible Modelling Framework (FMF) software (version 1.3) (Harland, 2013). Not only is the FMF software a matured spatial microsimulation software (Lovelace and Dumont, 2016, p. 10), but it is also the most user friendly of the available options, some of which are highlighted in Appendix A.3.2. With the aid of the FMF software, a generalized synthetic micro-population of the study area is simulated, which is then used to estimate the small-area number of sexually active people and other relevant MICS 5 indicators. The next section considers some noteworthy limitations of SMM in the context of the current study, while the validation of SMMs is discussed and implemented in Appendix A.1.

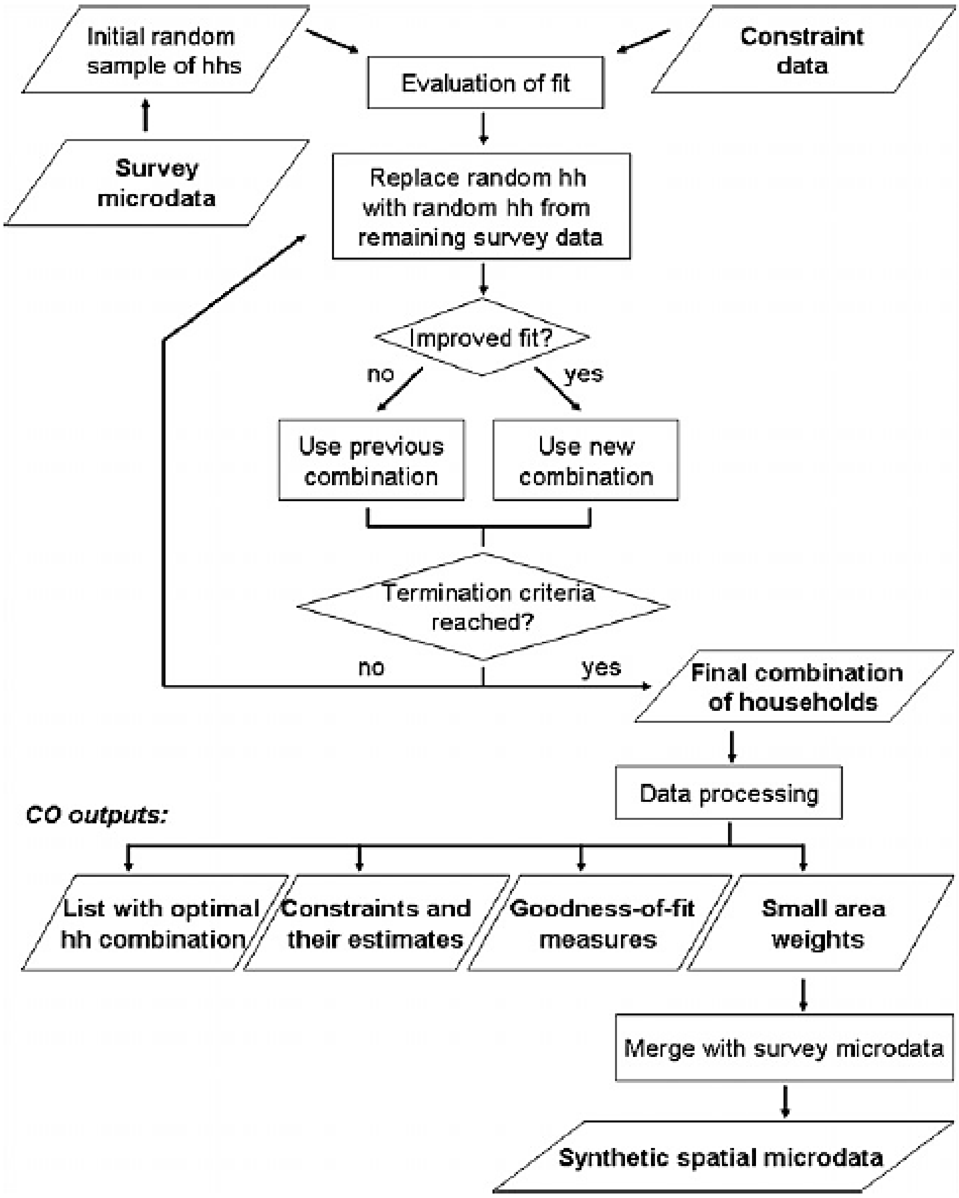

Figure 3-3 Simplified flowchart of CO with simulated annealing (NB: hh is household) (Hermes and Poulsen, 2012a, p. 285)

3.3.2.5 Limitations and Critiques of Spatial Microsimulation

SMM is critiqued as comprising more technical knowledge than theory (Halpin, 1999). They are relatively complex, requiring significant computing and data handling requirements, are costly to build and maintain, and usually require a team of developers comprising a variety of expertise. Also, these models are limited by the assumptions they embody, their design, the simulation algorithms employed as well as data quality and coverage issues (Brown and

Harding, 2005; Rahman and Harding, 2017). A key and significant weakness of SMMs is its inability to deliver intervals of uncertainty (i.e. confidence intervals) around the central point estimate of the small-area population attributes it produces (Rao, 2005; Chatterjee *et al.*, 2008; Nagle *et al.*, 2014; Tanton *et al.*, 2014; Whitworth *et al.*, 2017). Consequently, it is advisable to be explicit about these considerations by interpreting the results of SMM in light of its limitations and capabilities.

Other specific limitations of static SMM include: data quality, effects of the spatial constraints, and representativeness of the survey microdata (Tanton and Edwards, 2012). On data quality limitations, the input population must be available at the individual-level (i.e. a microdata). The reliability of spatial constraints is particularly problematic because census data often exclude people in non-private dwellings like hospital wards, school hostels, military barracks, prisons, aged care and nursing homes etc. The categorization of the spatial constraint variables must match the categories in the microdata. Where this is not the case, a regrouping of the variable categories must be performed to ensure this match.

In addition to the quality of the input data, the number and appropriateness of spatial constraints influence the quality of a SMM output; therefore, the selection of appropriate constraint variables is a key aspect of the modelling process (Burden and Steel, 2016a; Campbell and Ballas, 2016). More detailed constraints, as well as a larger sample size of microdata enhances the accuracy of a SMM (Ryan *et al.*, 2009); however, because of limitations of computational time (with simulated annealing) and a need to achieve convergence (with deterministic reweighting), a limited number of constraints has to be chosen (Chin and Harding, 2006; Tanton, 2011). Despite this, a variety of personal and demographic characteristics should be included as spatial constraints, especially in applications where the output of a SMM is intended for multiple uses, or where constraint variables with appropriate correlations with the target variables may be unknown (Birkin and Clarke, 2011). These latter considerations are particularly relevant to the current study which is not only equity-sensitive, but wherein multiple variables of the synthetic population are relevant to deriving small-area estimates of the health-related MICS 5 indicators.

3.3.3 Analyzing Spatial Accessibility of Primary Healthcare Services

The third research objective of this doctoral thesis is concerned with the small-area analysis of spatial accessibility of PHC services. There are many standard indicators for measuring healthcare coverage/accessibility (WHO, 2010, 2015; Health Finance and Governance (HFG) Project, 2017). These include: number and distribution of health facilities (offering specific services) per 10,000 population and the distribution of health workers by occupation/specialization, region, place of work and sex. However, many of these indicators are not available at a spatial scale that is appropriate for planning at the subnational or local level (Johnson *et al.*, 2010; Sridhar, 2016). Hence, one key contribution of this research project is the modelling of healthcare accessibility at a fine spatial scale, specifically the optimized small-area analytical zones, which are synonymous with extant wards.

The spatial accessibility of healthcare services is typically influenced by the availability of relevant geospatial and attribute details on three crucial variables; namely: the population need, the healthcare services/facilities, and the intervening medium between the former and the latter (especially transportation) (Guagliardo, 2004; Tanser *et al.*, 2010; Henry and McDonald, 2013). Owing to its complex nature, a myriad of parameters and operational decisions are relevant to analyses of spatial accessibility. These are outlined by the standard framework for analyzing spatial accessibility, illustrated in Figure 3-4 (Liu and Zhu, 2004; Morrissey, 2015; Apparicio *et al.*, 2017). Whereas aspects of 'concept formulation' are addressed in preceding chapters, the remainder of this section is concerned with facets of 'measure selection and specification' relevant to the current study. Thus, the next sub-section discusses the estimation of small-area needs (or potential demands) of primary healthcare services.

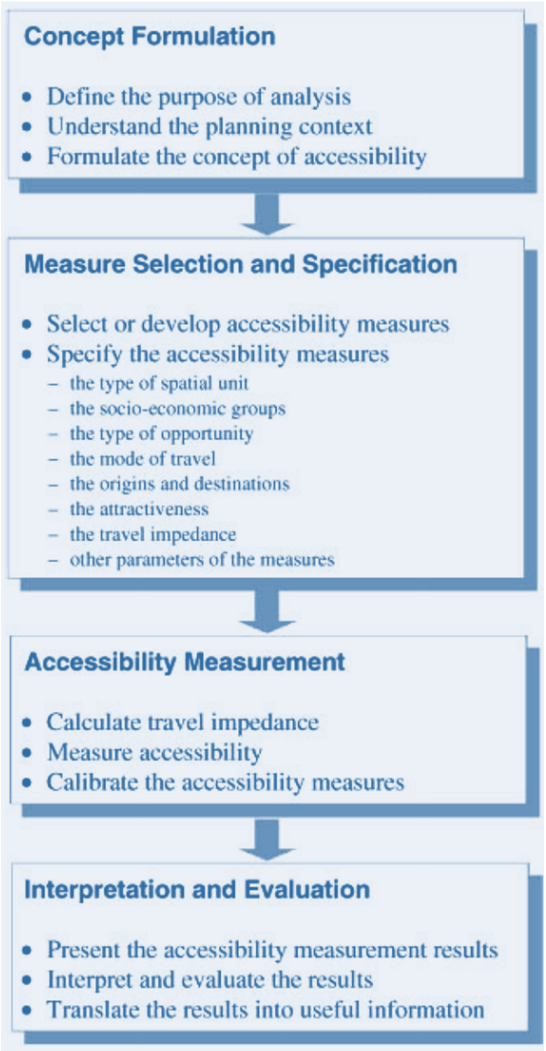

Figure 3-4 Standard framework for analyzing spatial accessibility (Liu and Zhu, 2004, p. 47)

3.3.3.1 Estimating Small-Area Healthcare Needs (or Potential Demand)

In the literature review chapter (i.e. Chapter 2), some discussions of needs assessment for healthcare are featured, especially in Sections 2.3.1. The emphasis of Section 3.3.2 is on the estimation of the need for specialized (or hard to estimate) primary healthcare services such as HIV/AIDS and sexual and reproductive health services. Notice that the epidemiology of a health condition like HIV/AIDS as well as confidentiality issues make HIV/AIDS-related data very difficult to access. Therefore, this is the focus of Chapter 5 for which the robust method of SMM is utilized. The logic of health needs assessment in this thesis is that while general primary healthcare services (like ANC, malaria, family planning) collectively inform the optimization of PHC services' spatial re-organization and/or expansion in the study area, the need for specialized PHC services like HIV/AIDS services informs the prioritization and rationing of HIV/AIDS-related services within an optimal constellation of PHC facilities. This section therefore corroborates previous discussions with an emphasis on the small-area estimation of general primary healthcare needs.

In the context of public health, "need describes the prevalence of health conditions that should be addressed by healthcare services" (Cromley and McLafferty, 2012, p. 308). There are many ways of measuring and analyzing healthcare needs, a process that is data-driven (Tanser *et al.*, 2010). A combination of demographic, socioeconomic and health outcomes indicators are typically used by health planners in defining needs (Cromley and McLafferty, 2012). For example, Cromley and McLafferty (2012) note that the number of pregnant women or the number of women of childbearing age can be used in describing the need for antenatal care services. Details on the computation of population fertility, reproduction and mortality measures as well as other measures of healthcare needs abound (Bowling, 2014b; Grundy and Murphy, 2015). For analysis of spatial accessibility of PHC services in this study, small-area needs for healthcare services are derived from relevant WorldPop gridded demographic data through zonal statistics (Lloyd *et al.*, 2017; Tatem, 2017). These univariate demographic measures of healthcare need are similar to the denominators of relevant Multiple Indicator Cluster Survey (MICS) indicators of the UNICEF. This is a demographic approach of needs estimation which is well supported by authors like Tanser *et al.* (2010, p. 571) who note that derived data products that represent populations as a pseudo-continuous raster format are veritable data sources for characterizing small-area population in the estimation of healthcare need.

Owing to the under-resourced healthcare systems of LMICs, data on even the most prominent healthcare problems are often scarce or unreliable[31] (WHO, 2000; Gething *et al.*, 2006). Consequently, statistical modelling techniques may be used to estimate the spatial distribution of population subsets of interest (Lawson, 2013). Furthermore, the prevalence rates of a given condition (such as malaria, HIV, or other vector-borne diseases) can be predicted by linking available survey data to demographic or environmental covariates (Tanser *et al.*, 2010, p. 572). This is a popular approach that has been used (especially in spatial epidemiology) for estimating the population at risk of various health conditions (Rogers, 1991; Snow *et al.*, 1999, 2005; Diggle *et al.*, 2002, 2007; Clements *et al.*, 2006a; 2006b).

For this research project, specialized small-area healthcare needs (especially HIV/AIDS-related services) are estimated by linking Multiple Indicator Cluster Survey (MICS 5) microdata to a derived pseudo-continuous raster representation of health-relevant population characteristic, the WorldPop Project. Spatial microsimulation which is introduced in Section 3.3.2 and implemented in Chapter 5 is used for the small-area estimation of relevant multivariate healthcare attributes in this project. The next section considers measures of healthcare services' supply.

3.3.3.2 Quantifying Primary Healthcare Supply

Mapping the spatial characteristics of a healthcare system, such as the location and attributes of facilities (in terms of personnel and services provided), is conceptually straightforward because most facilities from which healthcare services are provided (such as hospitals and clinics) have an explicit fixed spatial location (Tanser *et al.*, 2010, p. 571). However, there is a noteworthy difference between the location of healthcare facilities and the location of healthcare services. Only information on the physical location of facilities is required in assessing the former, while additional information on the characteristics of services offered by each facility (such as type, capacity and quality) is required for the latter. Thus, a consideration of the quantity of service supply is distinct and superior to using only facility location data. There are also some difficulties in defining the precise spatial location of some types of healthcare services. For instance, even though community-based services have an inherent geographical location, they are less straightforward to spatially characterize and then collect data on these services since health workers visit patients in their own homes (Krout,

[31] See also Section 4.1 and https://wennbergcollaborative.org/data-statement/ (Accessed 18th July, 2020)

1994). The geography of mobile healthcare services is also potentially complex (Alexy and Elnitsky, 1996) because to fully define their location, detailed data on their movements and schedule is required (Tanser *et al.*, 2010). This thesis is concerned with the location of PHC services offered in facilities with fixed locations.

In LMICs (like Nigeria), it can be extremely challenging to obtain reliable data on fixed and mobile healthcare services (Noor *et al.*, 2004). However, the Nigeria Millennium Development Goal Information System (NMIS) database provides relevant baseline heath facility dataset last updated in 2014. This database provides baseline geographic and attribute details on all fixed healthcare facilities in Nigeria. It indicates the availability of the following healthcare services in each facility as a Boolean variable: Caesarean Section (CS), Maternal Health Service (MHS), Antenatal Care (ANC), Skilled Birth Attendants (SBA), Family Planning Services, Child Health Services (CHS), malaria treatment (with Artemisinin Combination Therapies [ACT]). It also details the types and number of fulltime healthcare personnel available in each facility (i.e. Doctors, Nurses, Midwives, and Community Health Extension Workers (CHEWs)). The service supply for this thesis is therefore computed as service availability (boolean) multiplied by personnel-weighted staff count. The applied weighting is similar to that implied by the Minimum Ward Healthcare Package of the National Primary Healthcare Development Agency (NPHCDA, 2012), as shown in Table 3-4.

Table 3-4 Weighting scheme of various types of healthcare personnel in the study area

Type of Healthcare Personnel	**Weight**
Doctor	8
Nurse	4
Nurse Midwife	2
CHEW	1

Amongst other benefits, this index effectively corrects an anomaly in the dataset in which some hospitals without any record of personnel have records of services' availability and vice versa. Notice also that with the partial exception of Malaria Treatment (with Artemisinin Combination Therapy (ACT)), these baseline services are highly related to Sexual and Reproductive Health (SRH), which receives extensive attention in the current SDG era (Starrs and Anderson, 2015; Starrs *et al.*, 2018). For example, under the health goal (i.e. SDG 3), Target 3.7 states that "by 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes". Similarly, under the gender equality goal, target 5.6 aims to "ensure universal access to sexual and reproductive health and reproductive rights" (UN, 2015). Therefore, in addition to computing a proper index of healthcare supply, precise small-area estimation of the need for these services is invaluable both to the SDG agenda and to further analysis of spatial accessibility in this thesis.

A more precise index of healthcare supply incorporates the number of hospital beds and/or wards as well as medical personnel (Unal *et al.*, 2007). However, this is more relevant to inpatient services as opposed to out-patient services like most Primary Healthcare (PHC) services (in the study area). Moreover, a hospital with abundant wards and/or beds remains deficient in healthcare supply if there is a shortage of relevant healthcare personnel. It is therefore not surprising that in addition to specifying Medically Underserved Areas (MUAs), the US also specifies Health professional Shortage Areas (HPSA) as a corroborative measure of healthcare deprivation (Wang and Luo, 2005; Ricketts *et al.*, 2007; Streeter *et al.*, 2020). This implies that in this study, the supply index for PHC services like C-S and SBA can be improved upon by incorporating variables like hospital ward and/or bed count because these are typically in-patient services, unlike the other PHC services in the study area. However, the health facility data source for this project (i.e. the NMIS database) does not contain this extra information. The next section considers the transportation network model of this thesis.

3.3.3.3 Modelling Travel-related Disincentive on a Transportation Network

In the analysis of spatial accessibility, six types of distance measures abound (Luo and Qi, 2009; Apparicio *et al.*, 2017). These include: Euclidean distance (straight line), Manhattan distance, and travel distance/time (transportation network path). Travel time is the most realistic representation of transport-related disincentive because of its extensive ability to recognize variations in travel disincentive, such as travel speeds, speed limits and diurnal traffic congestions (Shahid *et al.*, 2009; Delamater *et al.*, 2012; Henry and McDonald, 2013). Therefore, unlike previous studies which use GIS to calculate road distances (Kalogirou and Foley, 2006), the travel impedance variable for this study is the travel time on a road network, which varies by road type/quality (Martin *et al.*, 2002). The network analyst of ArcGIS 10.5 software is used to model transportation characteristics on routes in the study area following standard procedures (Mitchell, 2012).

Although the accessibility analysis of this project considers only travel time by *'okada*[32]*'*, the transportation network model considers travel time via three transport media, namely: trekking, *'okada'* and 'car' because they are the most popular transportation mediums for potential hospital patients in the study area. These travel media have varying speeds and pliability depending on the road types of various segments. For instance, cars cannot navigate narrow paths or extremely rough roads, which are pliable by *'okada'*. However, cars can travel faster than *'okada'* on paved roads. Hence, in the transportation network model of the current study, travel time varies based on both the transportation medium as well as the road type (Manjia *et al.*, 2018, p. 158). The specific technique of modelling travel time in the form of Origin-Destination (O-D) matrices is explained in Section 6.2.2, whereas the next section turns to a discussion of the analysis of spatial accessibility in the study area.

3.3.3.4 Computing Indicators of Spatial Accessibility of Primary Healthcare Services

In analyzing spatial accessibility, zonal (or group) accessibility is often differentiated from individual accessibility, even though some attempts have been made to co-analyze both facets (Neutens *et al.*, 2008). This thesis is concerned with zonal accessibility (otherwise known as place-based accessibility) because it is more relevant to spatial dimensions of public health planning and policymaking. An overview of place-based methods of spatial accessibility is presented in Figure 3-5, while individual accessibility is well-covered (Kwan, 1998; Hsu and Hsieh, 2004; Neutens *et al.*, 2010). Analysis of spatial accessibility can be performed using either vector or raster data models of GIS by considering least-cost paths as well as catchment areas of need and/or supply (Delamater *et al.*, 2012). The network data model, which is an extension of the basic vector data model enables robust specification and/or estimation of travel time and other relevant travel-related modelling attributes for realistic small-area analysis of spatial accessibility (Kwan and Hong, 1998; Shahid *et al.*, 2009; Schuurman *et al.*, 2010). While extensive coverage of raster-based methods for analyzing spatial accessibility abound (Messina *et al.*, 2006), some of their important downsides are noteworthy. They may produce unexpected results in routing applications (Upchurch *et al.*, 2004; Sander *et al.*, 2010). Depending on the geometric complexity of the road network in a study area and the chosen spatial resolution of a project, travel time may be over/under-estimated by raster models (Delamater *et al.*, 2012). Therefore, aside from being the most popular GIS data model for

[32] An 'okada' is a smallish motorcycle used for commercial transportation in Nigeria.

analyzing spatial accessibility, the vector data model is the choice model for the current research project in order to take advantage of the extensive benefit of its network data model (Delamater *et al.*, 2012).

Detailed explanations of various zonal vector-based methods for analyzing the spatial accessibility of healthcare services abound in many textbooks (Cromley and McLafferty, 2012; Henry and McDonald, 2013; Wang, 2014b). As shown in Figure 3-5, despite some noteworthy limitations, the Two-Step Floating Catchment Area (2SFCA) method is a remarkable improvement over other relevant methods (such as the Provider-to-Population Ratio (PPR) and proximity to service provider(s)) (McGrail, 2012; Vo *et al.*, 2015). It is therefore well-established that variants of the 2SFCA methods (Luo and Wang, 2003; Wang, 2014b) and the gravity-based methods produce realistic indices of spatial accessibility. It has also been proven mathematically that the Enhanced 2SFCA (E2SFCA) method and Gravity-based methods have essentially the same properties in terms of total accessibility score and study area supply-to-demand ratio (Wang, 2014a, p. 99).

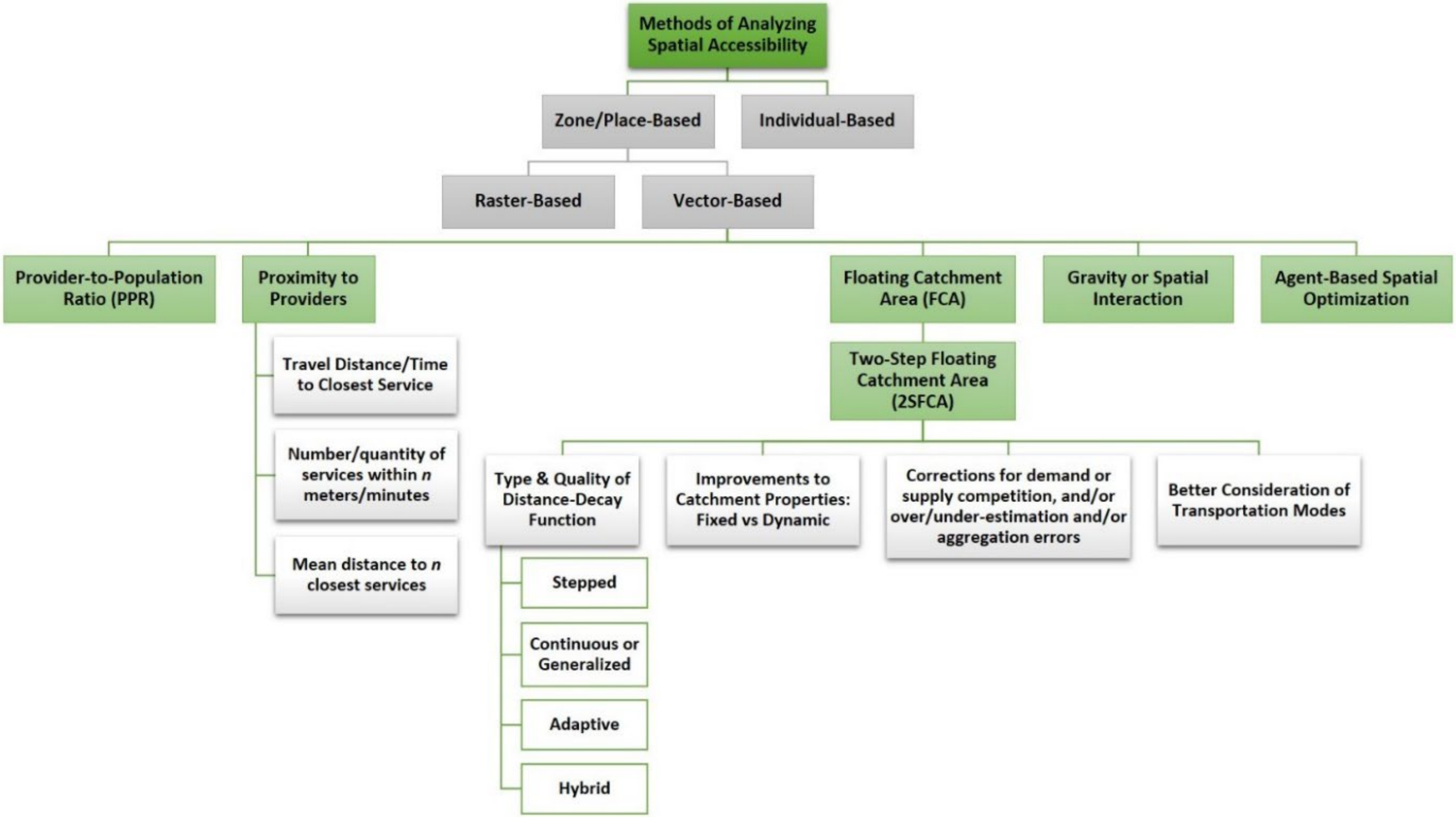

Figure 3-5 Overview of zone-based methods of analyzing spatial accessibility (Author, 2019)

Building on the idea of spatial decomposition (Radke and Mu, 2000), the classic 2SFCA method developed by Luo and Wang (2003) comprises two main steps:

1. Calculate the supply-to-demand ratio within a user-specified catchment (say 30-minutes' drive time) for each supply point.
2. For each demand location, search for all supply locations that are within the chosen service/catchment area, then sum the associated supply-to-demand ratio computed in Step 1.

A major downside of the classical 2SFCA method is that in its first step, the notion of distance-decay is neglected by assuming that all demand points within the catchment area of a supply point have equal proximity. Thus, it assumes that healthcare accessibility is constant within a user-specified catchment distance/time. For instance, large geographical regions with a much-dispersed population may require the use of large catchments, such that within a default catchment of 30 minutes, some demand points may be at a 5 minutes travels time while others are at a 28 minutes travel time to the supply point. This therefore results in an overestimation of potential demand within each supplier's catchment (Wan *et al.*, 2012b).

To resolve these limitations, various improvements to the 2SFCA methods abound, starting with the E2SFCA method (Luo and Qi, 2009; Qingming *et al.*, 2011; Wan *et al.*, 2012a) and its associated variant, the Generalized 2SFCA (G2SFCA), which incorporates the notion of distance-decay into the original 2SFCA conceptualization (Dai, 2012; Lee Deborah *et al.*, 2018). The original E2SFCA method features step-wise distance-decay weighting based on three or more drive time zones/catchments. For instance, in the catchment of a particular healthcare supplier, demand points within 0 – 10 minutes receive the highest distance-decay weight, which is greater than the weight for demand points of > 10 – 20 minutes, which in turn is greater than weight for demand points of > 20 – 30 minutes and so on. The G2SFCA method computes continuous distance-decay weights for each demand point, based on the adopted type of distance-decay function for a given application (Thill and Kim, 2005, p. 32; Wang, 2014b; Jamtsho *et al.*, 2015, p. 1585; Chen and Jia, 2019, p. 1740). Thus, both the E2SFCA and G2SFCA methods are more conceptually sound than the original 2SFCA method (Wang, 2014b, p. 100). This thesis features some improvements to the G2SFCA variant with a view to increasing its sophistication and the resulting fidelity of spatial accessibility indices obtained for the current study area. In so doing, some well-known dilemmas of the G2SFCA method are addressed, such as choosing the appropriate: (A) distance-decay function and coefficient as well as (B) the types and size of the catchment area to use in a study context (Apparicio *et al.*, 2017). Even though these contentions cannot be confidently settled without analyzing real-world travel behaviour (Wang, 2014a, p. 101), there are relevant guidelines in the literature which inform the analytical decisions of the current thesis.

A. Choosing an appropriate distance-decay function and coefficient

Depending on the hypothetic or verified health-seeking behaviour of the target population in a study area, the different forms of potential distance-decay functions that can be utilized include:

- Inverse power (Hansen, 1959; Unal *et al.*, 2007; De Vries *et al.*, 2009; Schuurman *et al.*, 2010),
- Negative linear (Schuurman *et al.*, 2010; Langford *et al.*, 2012),
- Exponential (Wilson, 1969; De Vries *et al.*, 2009; Delamater, 2013; Jamtsho *et al.*, 2015),
- Gaussian (Shi *et al.*, 2012; Wan *et al.*, 2012a),
- Log-logistic (S-Shaped) (Delamater *et al.*, 2013),
- Kernel density (or Epanechnikov kernel) (Dai and Wang, 2011; Wang, 2012, p. 1106),
- Butterworth filter functions (Langford *et al.*, 2012).

Furthermore, from these basic distance-decay specifications, a combination of discrete choices or a hybrid form (such as combining kernel function with a gaussian function for various ranges) can also be used to specify the distance-decay rule for a particular application, as shown in Figure 3-6D (Wang, 2012, p. 1106). In sum, these distance-decay functions can be stepped, continuous, adaptive, or hybrid (Paez *et al.*, 2019, p. 2), as outlined in Figure 3-5. The overall effect of these distance-decay weightings is that with increasing distance to a service supply point comes lower distance-decay weights, and by implication, a greater travel-related disincentive for service utilization. The ways in which distance-decay effect is conceptualized in the 2SFCA, E2SFCA and G2SFCA are illustrated in Figure 3-6.

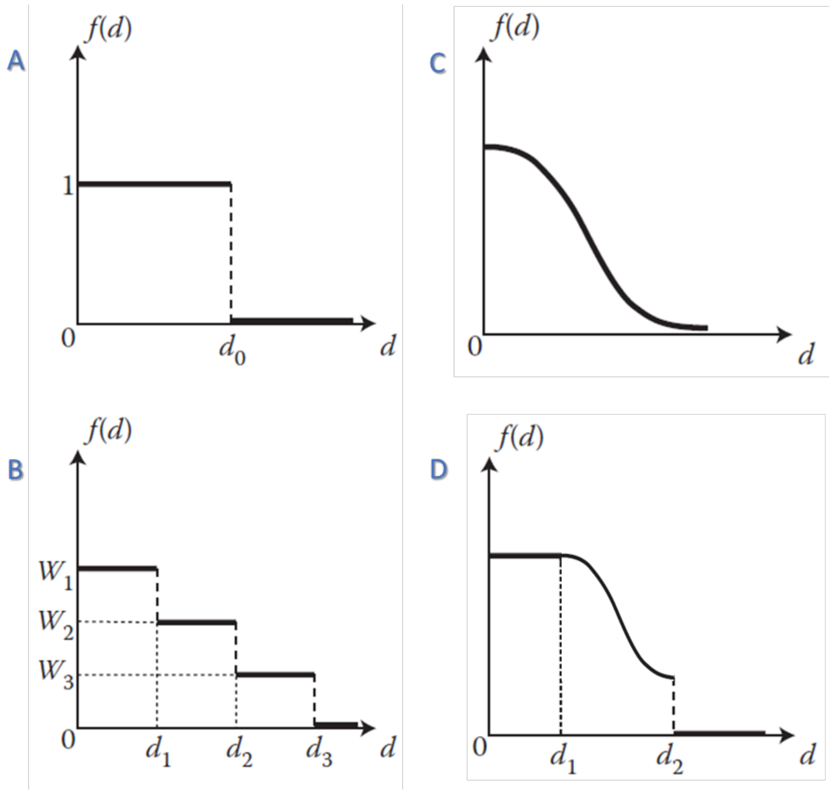

Figure 3-6 (A) Binary distance-decay weighting of 2SFCA; (B) Multiple step-wise distance-decay weighting of E2SFCA; (C) continuous weighting based on a generalized distance-decay function in G2SFCA (featuring a Gaussian function); (D) three-zone hybrid function (featuring a Gaussian function in Zone 2, the middle zone) (adapted from Wang (2014a, p. 101)).

Among other things, the G2SFCA method employed in this doctoral thesis features a continuous gaussian distance-decay function. Thus, a Gaussian G2SFCA algorithm is implemented for estimating small-area indices of spatial accessibility in the study area. Figure 3-6C shows that the (continuous/generalized) Gaussian function portrays a continuously gradual distance-decay effect close to a facility, a steeper decay farther away within the user-specified threshold distance/time and no interaction outside the user-specified threshold. In agreement with Kwan's (1998) assertion that a Gaussian distance-decay function provides the best fit for real-world travel patterns, it is adopted in this study (Pan *et al.*, 2015, p. 264). The distance-decay coefficient of the Gaussian function also has the advantage of being directly related to real-life distance/times measures (and units). This choice is also informed by the author's empirical experience and understanding of the study area population. Furthermore, a researcher can also determine the distance-decay function and coefficient that best fits the actual travel patterns of a study context by using empirical data on patients' travels to health services (Cromley and McLafferty, 2012, p. 322; Wang, 2014b, p. 101). To accomplish this, statistical methods like regression, linear programming, Particle Swarm Optimization (PSO) and Monte Carlo Simulation can be employed (O'Kelly *et al.*, 1995; Thill and Kim, 2005; Wang, 2007; Scott and Horner, 2008; Liu *et al.*, 2012; Xiao *et al.*, 2013). Alternatively, distance-decay functions (and their coefficients) calibrated for one study area can be used to model spatial accessibility in another study area, albeit not without limitations and problems (see for example Knox (1978)). Having chosen a befitting distance-decay function, a researcher can also address the problem of choosing an appropriate coefficient by calculating potential accessibility over a series of distance-decay coefficients and exploring the stability of the observed patterns of accessibility, using relevant statistical methods like factor analysis (Cromley and McLafferty, 2012, p. 324). The latter approach is adopted for choosing an appropriate distance-decay coefficient for the current study, as explained in Appendix A.2.

A few caveats associated with using the Gaussian distance-decay function in G2SFCA algorithms are worth noting. Gaussian G2SFCA methods assume that the associated travel data is normally distributed, such that the distribution of travel time/distance in a study area is similar to a bell curve (i.e. a normal distribution) (Vo *et al.*, 2015). This implies that resulting distance-decay weights will exhibit smaller statistical variance for a small catchment size. Hence, if variable/dynamic catchments are utilized, two or more demand points that are equidistant to a supply point would receive different distance-decay weights as a function of the size of their respective catchments. In other words, there is probably a problem of non-standardization of distance-decay weights for Gaussian G2SFCA methods that incorporate variable/dynamic catchment area sizes, such as the current thesis. Types of catchment areas used in G2SFCA algorithms are considered next.

B. Choosing an appropriate type and size of catchment areas

In 2SFCA methods, the catchment area size represents the maximum travel distance (i.e. the service range) beyond which there can be no interaction between demand and supply points in a study area (Chen and Jia, 2019, p. 1741). It approximates the service range (i.e. the maximum travel distance/time) of potential care seekers; hence, the determination of both the type and size of catchments is a matter of crucial importance (Apparicio *et al.*, 2017). In some studies, 30 minutes is an appropriate catchment size for the analysis of spatial accessibility of healthcare (Luo and Wang, 2003; Delamater *et al.*, 2012; Pan *et al.*, 2015), whereas in others, a catchment size of 60 minutes is popular because of the notion of the **'golden hour' rule** (Lerner and Moscati, 2001; Billi *et al.*, 2007; McGrail, 2012). While these predefined thresholds are useful in determining the degree of accessibility of healthcare services within this maximum (or standard) travel range, extremely isolated localities are both excluded and assumed to all be equally inaccessible. Clearly, this is an unrealistic assumption in many under-resourced contexts like the study area, which often contain some extremely remote and isolated communities that are outside these standard travel thresholds (of 30 or 60 minutes). Consequently, the need to extend the size of catchment areas in order to include isolated localities is well-acknowledged (McGrail and Humphreys, 2009b; Wan *et al.*, 2012a, 2012b).

Ideally, the size of catchment areas in various localities and for various service types is a function of both the activity space of customers and travel-related disincentive of service utilization, as well as service quality/attractiveness, mobility status, individual age, income and local context (rural-urban) (McEachern and Warnaby, 2006; Yang *et al.*, 2006; Wang, 2012; Morrissey *et al.*, 2013a, p. 215). This explains why rural areas are typically ascribed larger catchment areas than urban areas since rural dwellers tend to be more willing to travel long distances in search of services and commodities (such as healthcare and food), owing to their limited proximal opportunities (Arcury *et al.*, 2005; McGrail and Humphreys, 2009c). Needy populations are also more willing to travel longer distances for tertiary/specialist healthcare services than primary/general healthcare services (McLafferty, 2003). This also implies that distance-decay parameters will be different for each type of service provider (Naylor *et al.*, 2019). However, a lack or complexity of relevant data on activity space and health-seeking travel behaviour obfuscates the determination of appropriate catchments area sizes and distance-decay parameters in various studies of spatial accessibility (Luo and Qi, 2009; Wang, 2012); thus, these decisions have to be based on sound theoretical frameworks, policy goals as well as a researcher's subjective knowledge of a study area (Jamtsho *et al.*, 2015).

The foregoing suggests that fixed catchment area sizes do not properly account for the diversity of population density that characterize some large study areas which contain an intermix of rural and urban contexts, such as the current study. In addition to more willingness of rural dwellers to travel longer distances than urban dwellers (Arcury *et al.*, 2005; McGrail and Humphreys, 2009a; Haggerty *et al.*, 2014); a larger catchment size intuitively results for rural areas as a consequence of being much less densely populated than urban areas. This is because the service threshold requirement for the same types of healthcare services necessitates larger catchment areas for rural areas (Luo and Whippo, 2012). Furthermore, in 2SFCA methods, catchment area size has a number of noteworthy effects on computed spatial accessibility indices (McGrail and Humphreys, 2014, p. 3). These include: (1) for each supply point in Step 1, the population of need will increase for a larger catchment size, (2) For each demand point in Step 2, the number of supply points (being summed up) will increase as catchment size increases, (3) the weighting of the distance-decay function will have less effect with an increase in catchment size, implying more willingness to overcome travel-related disincentive in covering longer distance in search of healthcare. In effect, a larger catchment area size leads to stronger spatial smoothing of spatial accessibility indices by reducing their variability across space. Therefore, it is vital to vary the catchment size of 2SFCA methods by provider types and/or neighbourhood types (Yang *et al.*, 2006) or geographic context (e.g. larger in rural areas and smaller in urban settings) (McGrail and Humphreys, 2009b, 2014). Consequently, this research project varies demand-side catchment area size by the nature of geographic context, especially variations in settlement population densities as explained further in Section 6.2.3.

From the foregoing discussions, it is apparent that variable/dynamic catchment areas are more realistic than fixed catchment area sizes, especially in large study areas with highly varied types of geographic contexts, like the current study area (McGrail and Humphreys, 2009c, 2014; Ni *et al.*, 2015). There are two main variants of dynamic/variable catchment areas (Chen and Jia, 2019, p. 1742), namely: Variable 2SFCA (V2SFCA) (Luo and Whippo, 2012) and the Nearest Neighbour-Modified 2SFCA (NN-M2SFCA) (Jamtsho *et al.*, 2015). In the V2SFCA method, the supply catchment is increased until the demands from the proximal service area exhaust its supply capacity; similarly, the demand catchment size is incrementally increased from a minimum of 10 minutes to a maximum of 60 minutes until a minimum provider-to-population ratio (1:3500) is reached. However, McGrail (2012, p. 4) rightly notes a crucial inadequacy of Luo and Whippo (2012) V2SFCA method. It does not adequately account for variations in local settlement patterns in relation to the spatial organization of healthcare services. Thus, needy population are expected to only travel further if the local access is below a minimum level. However, in reality, there is not this type of strict and/or direct relationship between the level of local accessibility (which is often unknown to many potential patrons) and travel-related health-seeking behaviour in most localities. Potential patrons often bypass proximal services and travel further even amidst available opportunities for local access (Akin and Hutchinson, 1999; Meade and Emch, 2010, p. 421; Federal Ministry of Health (FMoH), 2016, p. 88). Therefore, the current study implements a variant of the theoretically superior NN-M2SFCA type of dynamic catchment area (Jamtsho *et al.*, 2015), in which all potential demand points are expected to seek care within a pre-specified equal number of supply facilities. This is called an Optimized NN-G2SFCA (ONN-G2SFCA) method, discussed further in Section 3.3.3.5 below. Before that, the variety of possible improvements to the classic 2SFCA method as well as recent methodological developments in the analysis of spatial accessibility are summarized in the remainder of this section.

In sum, improvements of E2SFCA methods are based on any or a combination of the following aspects, as illustrated in Figure 3-5: (1) quality of the distance-decay function, (2) type of catchment, (3) accounting for (errors in) demand or supply – aggregation and/or competition (and/or inflation or deflation) and (4) enhancements to the variety of modes of transport (Chen and Jia, 2019, p. 1740). Thus, further to the E2SFCA method (Luo and Qi, 2009) and its related adaptations like the G2SFCA, there are various possible improvements to the original 2SFCA algorithm (Luo and Wang, 2003), aimed at improving the sophistication and consequent fidelity of derived spatial accessibility indices (Vo *et al.*, 2015; Plachkinova *et al.*, 2018; Chen and Jia, 2019; Paez *et al.*, 2019). These are outlined in Table 3-5 below.

Table 3-5 Outline of potential improvements to the classic 2SFCA method of analyzing spatial accessibility

Potential Improvements to the Classic 2SFCA Method (Luo and Wang, 2003)	**Example of Studies**
Enhanced 2SFCA	(Luo and Qi, 2009)
Generalized 2SFCA	(Wang, 2014a, p. 99)
Optimized 2SFCA	(Ngui and Apparicio, 2011)
Hierarchical 2SFCA	(Jin *et al.*, 2019)
(Enhanced) Variable 2SFCA	(Luo and Whippo, 2012; Dewulf *et al.*, 2013; McGrail and Humphreys, 2014; Ni *et al.*, 2015)
Nearest-Neighbour Modified 2SFCA	(Jamtsho *et al.*, 2015)
(Extended) Kernel Density 2SFCA	(Dai and Wang, 2011; Polzin *et al.*, 2014)
Three-step FCA	(Wan *et al.*, 2012b; Bell *et al.*, 2013)
Modified 2SFCA	(Delamater, 2013)
Multi-transportation 2SFCA	(Mao and Nekorchuk, 2013; Langford *et al.*, 2016; Lin *et al.*, 2018; Tao *et al.*, 2018; Ni *et al.*, 2019)
Huff Model-based 2SFCA	(Luo, 2014)
Domain-Based 2SFCA	(Siegel *et al.*, 2016)
Commuter-based 2SFCA	(Fransen *et al.*, 2015)

Despite this diversity of advancements in the sophistication and rigour of the 2SFCA methods, some dilemmas about the appropriate criteria for a given project still abound (Plachkinova *et al.*, 2018). These are matters of operational decision, informed by the nature and purpose of a given research project (Neutens *et al.*, 2010, p. 2), most of which are addressed in Section 3.3.3.5 in the context of the current thesis. Furthermore, these dilemmas have motivated a recent introduction of spatial optimization methods for spatial accessibility analysis, outside the precincts of FCA and gravity methods.

Spatial optimization models are recently being used to estimate spatial accessibility by matching healthcare need and supply using both the relative crowdedness of each supply and patient-supplier distance as the basis for determining each patient's travel distance and corresponding crowdedness (Nobles *et al.*, 2014; Gentili *et al.*, 2015; Li *et al.*, 2015, p. 2). This novel approach, which tends to offer considerable advantages over the 2SFCA family of methods (Li *et al.*, 2015; Gentili *et al.*, 2018), can be implemented by a Rational Agent Access Model (RAAM) algorithm (Saxon and Snow, 2020). In principle, RAAM is an agent-based model that predicts users' likely point of care utilization based on a robust formulation and uses this as a basis for computing an index of relative spatial accessibility. In so doing, it is responsive to the competitive effects of congestion while accounting for users' potential preferences. It is also able to simultaneously consider both travels from home and work as well as multiple travel modes, unlike many 2SFCA implementations (with the exception of Fransen *et al.* (2015)). Being an agent-based model, it is much more scalable than the E2SFCA family of methods, allowing it to efficiently estimate spatial accessibility for large study areas at very fine spatial scales as well as at individual levels (where appropriate data is available). However, RAAM is premised on the basic economic principle of the 'rational man', which assumes that potential service users have perfect knowledge of cost in the market space and therefore will always act rationally (Saxon and Snow, 2020, p. 7). In addition to other potential downsides associated with specifying appropriate modelling parameters, RAAM is therefore limited to the extent that this basic economic principle does not hold in real life. Being novel, RAAM's validity is not yet tested in many empirical situations since it has only been applied in very few studies. Furthermore, being based on very complex mathematical formulations (Nobles *et al.*, 2014; Gentili *et al.*, 2015), its implementation is not straightforward, requiring extensive programming skills (in python). Hence, it is not considered in the current study that sticks with improvements to the well-established E2SFCA family of accessibility methods. The next section explains the customized variant of 2SFCA method implemented in the current study, the ONN-G2SFCA.

3.3.3.5 Introducing a Bespoke G2SFCA Method: The ONN-G2SFCA Algorithm

Owing to a lack of universal standards in the application of 2SFCA methods of modelling spatial accessibility (Chen and Jia, 2019), the specific purpose of a research project often determines the appropriateness of operational decisions and specified parameters (Neutens *et al.*, 2010, p. 1615). Among other things, this research project implements an improved variant of the theoretically superior NN-M2SFCA type of dynamic catchment area, in which all potential demand points are expected to seek care within a pre-specified equal number of supply facilities (Jamtsho *et al.*, 2015). In this approach, the size and shape of supply-side catchment areas are varied in order to equalize the opportunity for care in every catchment, such that opportunity for care is a measure of the number of service points in a catchment area. This assures that catchment areas of densely populated and/or well-served localities are relatively smaller than those of sparsely populated and/or poorly served localities, as a function of the spatial organization of PHC services relative to various local contexts. Unlike the majority of similar studies, this is a more realistic empirical response to the fact that large travel distances result axiomatically from low population density (Saxon and Snow, 2020, p. 209). However, there is no standard yardstick for determining the number of nearest-neighbours (and by extension the base/smallest catchment area size) of the NN-M2SFCA method.

In filling this methodological gap in this thesis, the size of the smallest catchment is determined by the service range of the most remote locality in the study area. In this way, the proximity of the nearest supply point from the most isolated demand point is calculated and then used to enumerate supply points available to the most advantaged demand location within the same distance benchmark. This base catchment size is hereby called an '**index of disparity in service opportunities (IDSO)**' which is similar to the concept of accessibility or choice bias of McGrail (2012) and Jamtsho *et al.* (2015). This measure represents the number of service supply opportunities available to the most advantaged (i.e. accessible) location when the most disadvantaged (i.e. isolated) demand point can reach only one supply point. It is a proxy of potential population response to both remoteness and the resulting travel-related adaptation associated with large study areas comprising highly contrasting population densities. This IDSO is therefore used to cap the number of supply points for every other demand point in the ONN-G2SFCA algorithm of the current study[33]. In study areas without

[33] A ratio (such as 25%, 50%, 75% or any other function) of the IDSO can also be used in determining NN catchment sizes.

isolated localities that fall outside the standard 30- or 60-minutes travel thresholds, the base size of dynamic catchment areas can be determined using the number of supply opportunities within either 30 or 60 minutes (as the case may be) of the most disadvantaged demand point in the study area.

It can be argued that using the proximity of worst-case demand point as the basis for determining the base catchment area size as proposed in the current study is only relevant to 2SFCA algorithms with fixed catchment sizes since the NN-M2SFCA considers an equal number of finite nearest supply points regardless of their specific proximity to potential demand points. However, it is suggested that the use of IDSO (or its derivatives) in contrast to any other arbitrary number of nearest neighbours is an intuitive formulation because it is both data-driven and, by extension, context-sensitive. Consequently, it is very likely to better emulate the spatial dynamics of travel-related distance-decay variations across different geographic contexts in the study area. IDSO is likely to adequately capture variations in the relative abundance (or scarcity) of supply of various service types in any study area. Therefore, as shown in Table 6-1 (of Section 6.2.1), IDSO is different for various types of PHC services. Furthermore, it is a standard measure that can readily be compared to its fixed catchment area variants during sensitivity analysis or other types of comparative studies. However, it is worth noting that the use of an equal number of nearest supply points in determining the size of dynamic catchment areas is applicable only in studies that incorporate an appropriate distance-decay function. In this way, travel disincentive increases the further supply points are from a given demand location. Otherwise, equalizing the number of potential supply opportunities will invariably equalize accessibility indices in an area, save variations in the quantity of demand and supply in a system. Apparently, without distance-decay weightings, an IDSO-equalized variable catchment area analysis will misrepresent variations in spatial accessibility in any context. In addition to using the Gaussian distance-decay function in this study, potential accessibility scores for a series of distance-decay coefficients ranging from 5 to 25 minutes (at 5 minutes step-wise interval) are calculated and explored for each healthcare service in the study area, as explained in Appendix A.2.2. This forms the bases for choosing a stable distance-decay coefficient for this study, as explained in Section 6.2.3 (depicted in Figure 6-4B).

Against the foreground background, the current study implements a so-called **Optimized Nearest-Neighbour Gaussian Two-Step Floating Catchment Area (ONN-G2SFCA)** variant of the E2SFCA family of accessibility methods. The main characteristics of this ONN-G2SFCA method can be summarized as follows: (1) an optimized small-area analytical zoning system is used in computing the SPAIs; (2) dynamic catchment area sizes for demand points are used, which are based on *n* nearest supply points determined by an IDSO; (3) continuous gaussian distance-decay function is factored, whose coefficient is stable (4) resulting small-area SPAIs are aggregated to higher zones which are contextually meaningful in the study area, similar to Bell *et al.'s* (2013, p. 9) quasi 3SFCA method[34]; (5) other relevant parameters are relatively precise (or optimal) (Plachkinova *et al.*, 2018, p. 293), such as the estimates for need and supply per service as well as the travel-time estimates between various demand and supply points.

3.3.3.6 Synthesis of the Bespoke Small-Area Modelling of Spatial Accessibility

Most studies on spatial accessibility focus exclusively on the algorithm for computing the index of spatial accessibility (Vo *et al.*, 2015; Chen and Jia, 2019), with much emphasis on precisely modelling travel disincentive/impedance associated with the transportation network or medium. However, as discussed in the foregoing sub-sections, the analysis of spatial accessibility outstretches the precincts of the particular accessibility measure/algorithms adopted (such as the E2SFCA methods). It includes several other parameters whose choice could (either) generate different results and/or potentially result in significant measurement errors (Apparicio *et al.*, 2008, 2017, p. 2). For example, aside from being inattentive to the architecture of the zoning system used for the aggregation of need (Hewko *et al.*, 2002; Root, 2012; Dewulf *et al.*, 2013), most analyses of spatial accessibility pay poor attention to precise small-area estimation of need and supply of the particular healthcare services being studied (Plachkinova *et al.*, 2018, p. 293), with a few exceptions (Ngui and Apparicio, 2011; Bell *et al.*, 2013; Delamater, 2013). Thus, by paying detailed attention to these often neglected aspects, amongst other things, the current study makes strong contributions to relevant literature on spatial accessibility of healthcare, especially studies that implement the E2SFCA family of methods in data-scarce contexts like Nigeria (Root, 2012; Chen and Jia, 2019, p. 1755).

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[34] While Bell's (quasi-)3SFCA method is concerned only with minimizing aggregation-induced errors in the 2SFCA methods, the main 3SFCA method recognized in spatial accessibility studies (Wan et al 2012) incorporates competition effect amongst multiple suppliers within the catchment of a demand point by applying a selection weight (which is based on the number of available services in a demand point's catchment). However, this may not be relevant to the current study which has equalized the number of service opportunities within each demand's catchment by varying their size accordingly.

The approach of modelling spatial accessibility in this thesis is both intuitive and robust for the current study area whose population aggregation zones exhibit stark disparities in population density (see Section 4.3, especially Table 4-4). The ONN-G2SFCA algorithm of the current study is considered to be optimized because unlike other studies, the demand points of this study are the population-weighted centroids of optimized analytical wards (which are developed in Section 3.3.1). Among other benefits, this minimizes aggregation-induced errors in the current study (Bell *et al.*, 2013; Chen, 2019). In this way, the first and second as well as aspects of the third improvements (particularly the mitigation of aggregation-induced errors) to the classical 2SFCA methods discussed in Section 3.3.3.4 are featured in the current study (see Figure 3-5). Other noteworthy improvements that are outside the strict precinct of the 2SFCA methods are derived from Chapters 4 and 5. For instance, unlike other studies, Chapter 4 comprehensively handles scale-dependent aspects of the current study by developing an optimized zoning system of appropriate scale that is used in this thesis for modelling small-area spatial accessibility (Fischer, 2006, p. 38; Root, 2012; Chen and Jia, 2019, p. 1745). Furthermore, congruent with Plachkinova *et al.* (2018, p. 293), relatively precise small-area measures of both need and supply of particular PHC services are derived in Chapter 5 (for Sexual Health Services) as well as Sections 6.3.1 and 6.3.2. Lastly, the accessibility indices of this study are partly validated and corroborated in Chapter 7, in which relevant qualitative data elicited from localities identified as extreme Medically Underserved Area (eMUAs) are analyzed and discussed.

Even though other improvements are possible, some of which may have been implemented in cognate literature highlighted in Section 3.3.3.4 (and Table 3-5); not only are the corpus of improvements featured in the current study innovative; they are also adequate for realistically characterizing small-area variations in spatial accessibility of PHC services in the study area. Indeed, to the best of the researcher's knowledge, no single study has made improvements in all the aspects simultaneously considered in this thesis. For instance, dynamic catchments are varied stepwise according to rural-urban characteristics (McGrail and Humphreys, 2009b, 2014), while the Nearest-Neighbour catchments of Jamtsho *et al.* (2015) are based on Euclidean distance instead of realistic travel-time estimates as well as using a problematic number of nearest neighbours. This study uses dynamic catchment area size, which varies anisotropically according to the proximity of *n* nearest service points to each demand point. Unlike simplistic Euclidean distance measures, the proximity variable is travel time on roads, to *n* nearest services capped by an IDSO. Further empirical details on the ONN-G2SFCA implemented in this study are provided in Chapter 6, especially Section 6.2.3.

The next section explains qualitative aspects of the explanatory sequential mixed methods research design of this thesis, as discussed in Section 3 (see also Figure 3-1). This develops on the foregoing spatial analysis in at least two important ways. First, it validates and/or corroborates some of the findings from precedent spatial analytics. Second, it helps to overcome many of the downsides of quantitative/spatial analysis by sufficiently incorporating the socio-cultural context and subjective perspectives of the study population in line with the axiology of this thesis, as discussed in Sections 2.1 and 3.1.

3.4 Method of Qualitative Primary Data Collection

Qualitative data for this study were collected using Focus Group Discussions (FGD), which are very effective for collecting data on non-sensitive topics about values, beliefs, social norms and expectations (Tolley *et al.*, 2016). FGDs are very beneficial in studies in which interactions among study participants are useful in enriching the data collection process (Morgan, 1988). This study sought to elicit intensive data on communal healthcare-related issues; therefore, interactions within groups were helpful in establishing communal views on the themes discussed. Such interactions were mainly in the form of agreeing/disagreeing with other participants' observations or statements as well as corroborating or re-echoing the experiences or desires of other participants.

These FGDs were targeted at residents in the healthcare deserts of the study area, as revealed by the preceding spatial analysis section of 3.3 above. Research participants are people aged between 20 and 49 years old in these healthcare deserts. These are potential or actual users of healthcare facilities in the study area who also correspond with the typical age group of health-related surveys, such as the MICS 5 microdata that was used in the quantitative aspect of this study. The FGD explored perceived communal healthcare needs of the participants, their experiences and/or perception of accessibility to healthcare services, as well as their preferences or desires for the removal of their healthcare barriers. As there are multiple healthcare providers in Nigeria (comprising Public, Private, NGOs, faith-based and community healthcare providers), this study also sought to know the preferred service provider as well as the reasons for their preferred choice. In addition to formal/western healthcare services delivered at hospitals and clinics, there are Traditional, Complementary and Alternative Medicine (TCAM) providers and users in Nigeria (Dillip *et al.*, 2012; Abubakar *et al.*, 2013;

Lakshmi *et al.*, 2014; Agu *et al.*, 2018; James *et al.*, 2018; Peltzer and Pengpid, 2018). Therefore, this study also sought to know what types of medicine that were preferred by the respondents and why? In these discussions, the respondents were encouraged to share their personal or communal experiences and beliefs regarding the themes discussed. Before commencing the discussion, they were informed, among other things, that there were no right or wrong answers/responses to the various conversation prompts. They were all encouraged to freely express their views and experiences in as realistic a manner as possible.

A handheld digital audio recorder and a mobile phone were used for the audio recording of all group discussions. Prior to the discussions (and in addition to filling the consent forms), an information sheet was given to and discussed with the participants, detailing the expected nature of the discussions. Indeed, the field assistants used the same information sheets in discussing with potential participants at the time of their enlistment and recruitment for the group discussions. These fieldwork procedures are discussed further in relevant sub-sections.

3.4.1 The Fieldwork Sites

A detailed discussion of the study area, Kogi State, is provided in Section 1.5.1. It is explained that its three (3) senatorial districts are a good basis for designing the qualitative data collection procedure of this study because they possess distinct cultural characteristics. Kogi State was chosen as the study site for this research because it is construed as a microcosm of Nigeria (Omotola, 2008). In terms of the socio-cultural context of the three senatorial districts, indigenes of Kogi Central are mostly of the Ebira ethnicity, with a dominant Muslim population; the majority of the indigenes of Kogi East are of the Igala ethnicity and comprise a near equal mix of Christians and Muslims; Kogi West is mostly inhabited by the Okun ethnicity and are dominantly Christians. Group discussions were conducted in four wards spread across the three senatorial districts, as depicted in Figure 6-1. Two of these wards are in Kogi East, because it has a population that is approximately double that of Kogi central or Kogi West. In order words, Kogi east can be considered to constitute half the population of Kogi state. Based on the analysis of quantitative data (detailed in Section 3.3.3.3), these wards can be collectively categorized as healthcare shortage areas (or healthcare deserts); therefore they were selected for further intensive analysis using qualitative methods. Wards at the margins of the study area were not considered as potential intensive study sites because most analyses of spatial accessibility suffer from edge effects, including the current thesis (Pfeiffer *et al.*, 2008, p. 15). Edge effects imply that marginal areas are prone to errors because they are influenced by the demand, supply and transportation patterns of adjacent areas outside the study area. Within each ward, two communities were chosen, which were adjudged by field assistants as having the most acute difficulties in reaching locations of primary healthcare. Recruited field assistants for this study are indigenes of their respective wards; therefore, their first-hand knowledge and experience of the fieldwork localities could be relied upon. A breakdown of the sites visited is provided in Table 3-6, whereas Figure 6-1 depicts their location on a map.

*Table 3-6 Fieldwork sites of qualitative data collection in Kogi State, Nigeria (*see Figure 6-1)

Senatorial District	**Local Government Area**	**Ward**	**Community (Study Site)**
Kogi East	Dekina	Oganenigu	Ugbabo
			Aloko-Oganenigu
	Ofu	Ogbonicha	Ochi Ogbonicha
			Ofabo
Kogi Central	Adavi	Nagazi Farm Centre	Nagazi Uvete
			Nagazi Eba
Kogi West	Kabba	Aiyetoro-Kiri	Aiyetoro-Kiri
			Ike-Bunu

In these localities, the group discussions were conducted outdoors, in open places chosen by the participants in liaison with the field assistants. Informal meetings in rural communities in Nigeria are often conducted outdoors in open places, especially during dry seasons, because this is more convenient than meeting indoors owing to better ventilation and brightness.

Being very rural areas, most inhabitants of the study sites were people of low socioeconomic status, many of whom were secondary school certificate holders (please see Table 3-13 and Table 3-11, respectively). In some of the study sites, especially those in Kogi East, most of the participants were not literate in the English language. In Section 3.4.2 below, the procedures for recruiting research participants are discussed.

3.4.2 Sampling Procedure for Participant Recruitment

This qualitative research facet employs a stratified purposeful sampling technique (Mertens, 2019). This combines various sampling strategies, of which relevant subgroups are chosen as the basic strata for the sampling. From each of the strata, cases are then selected that meet the purpose of the data collection. In this study, the senatorial districts in the study area constitute the basic strata from which purposive cases (i.e. communities) were chosen for group discussions. These senatorial districts are the main units of socio-cultural differentiation in the study area, not least because they embody the three dominant ethnic groups (with various indigenous languages) in the study area. As the purpose of qualitative fieldwork is to explore the views, experiences and desires of indigenes of landscapes of extreme healthcare deprivation, communities within these extremely deprived places were the sites for group discussions across the three senatorial districts. In so doing, informed participants with a thorough understanding of access-related experiences in eMUAs were purposively recruited with a view to obtaining rich data on the research theme (Preissle *et al.*, 2015, p. 149). This type of sampling design can also be called stratified targeted sampling (Schensul, 2012, p. 85), of which senatorial districts are the strata within which places/communities of extreme healthcare deprivation are the targets. Organized this way, not only was the researcher able to discursively explore the overall socio-cultural experiences, perceptions and perspectives of healthcare-deprived respondents in the study area, the researcher was also able to tease out variations in the spatial patterns of these situated experiences, perceptions and desires.

In Nigeria, it is the practice that interested outsiders obtain permission from relevant community chiefs before carrying out any project within their respective jurisdictions. Field research assistants obtained the necessary permissions. They were also responsible for identifying and recruiting willing participants for the group discussions of this study. Once a total of eight participants were recruited, a date, time and venue for the actual group discussion was arranged by the field assistants in consultation with the participants. Detailed guidance on the recruitment of group participants was provided to the research assistants before the fieldwork. For instance, each group was designed to comprise an equal mix of females and males of age between 20 and 59 years. These participants are also expected to be members of various families within the said community, in order to elicit diverse perspectives. The resulting number and demographics of the research participants are discussed in Section 3.4.3 below.

3.4.3 The Number and Composition of Focus Groups

As a rule of thumb, group discussions should comprise 6 to 9 people per group, with a minimum of four groups for each category of the target audience (Krueger and Casey, 2009). More recently, Tolley *et al.* (2016) suggest that the number of group discussions of a study should be determined by the number of stratifying variables, the available human and financial resources and the available time for the study. In this regard, Tolley *et al.* (2016) rule of thumb is to conduct no less than two FGDs for each defining/stratification variable. They are also of the opinion that 8 to 10 participants per group are sufficient for producing a good and manageable discussion. Apparently, there are some slight variations in the structuring of group discussions prescribed by various authors.

With careful planning in line with the foregoing considerations, eight group discussions were conducted within two months, in various communities spread across the three senatorial districts of Kogi State. Details on the local communities of these group discussions are provided in Section 3.4.1 above (see Table 3-6). The primary stratifying variable for the qualitative data collection is the senatorial districts (which is congruent with the main socio-cultural distinctions in the study area); hence, at least two group discussions were conducted in each senatorial district, held at communities experiencing extreme healthcare deprivation (see Figure 6-1 for a map of the fieldwork sites). There were eight (8) participants per group, comprising 4 females and 4 males. Further details on the demographic composition of the group discussions are outlined in Table 3-7 to Table 3-13. Residents of rural communities in Nigeria are usually familiar with each other; therefore, it is highly likely that participants of each focus group are familiar with each other.

Table 3-7 Demographic attributes of the focus groups: Age distribution

		Senate District							
		Kogi Central		Kogi East		Kogi West		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Age (years)	Missing	1	6.3%	-	-	1	6.3%	2	3.1%
	20 - 24	3	18.8%	7	21.9%	3	18.8%	13	20.3%
	25 - 29	2	12.5%	-	-	3	18.8%	5	7.8%
	30 - 34	5	31.3%	5	15.6%	3	18.8%	13	20.3%
	35 - 39	2	12.5%	5	15.6%	2	12.5%	9	14.1%
	40 - 49	3	18.8%	11	34.4%	4	25.0%	18	28.1%
	50 - 54	-	-	1	3.1%	-	-	1	1.6%
	55 - 59	-	-	3	9.4%	-	-	3	4.7%
	Total	16	100.0%	32	100.0%	16	100.0%	64	100.0%

Table 3-8 Demographic attributes of the focus groups: Gender

		Kogi Central		Kogi East		Kogi West		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Gender	Female	8	50.0%	16	50.0%	8	50.0%	32	50.0%
	Male	8	50.0%	16	50.0%	8	50.0%	32	50.0%
	Total	**16**	**100.0%**	**32**	**100.0%**	**16**	**100.0%**	**64**	**100.0%**

Table 3-9 Demographic attributes of the focus groups: Ethnicity

		Kogi Central		Kogi East		Kogi West		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Ethnicity	Ibira	16	100.0%	-	-	-	-	16	25.0%
	Igala	-	-	32	100.0%	-	-	32	50.0%
	Yoruba/Kabba/ Okun	-	-	-	-	16	100.0%	16	25.0%
	Total	16	100.0%	32	100.0%	16	100.0%	64	100.0%

Table 3-10 Demographic attributes of the focus groups: Religion

		Senate District							
		Kogi Central		Kogi East		Kogi West		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Religion	Missing	1	6.3%	3	9.4%	2	12.5%	6	9.4%
	African Traditional Religion	1	6.3%	-	-	1	6.3%	2	3.1%
	Christianity	3	18.8%	19	59.4%	13	81.3%	35	54.7%
	Islam	11	68.8%	10	31.3%	-	-	21	32.8%
	Total	16	100.0%	32	100.0%	16	100.0%	64	100.0%

Table 3-11 Demographic attributes of the focus groups: Educational qualification

		Kogi Central		Kogi East		Kogi West		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Highest Education	Missing	1	6.3%	1	3.1%	1	6.3%	3	4.7%
	First Degree	4	25.0%	1	3.1%	1	6.3%	6	9.4%
	Higher National Diploma (HND)	-	-	1	3.1%	2	12.5%	3	4.7%
	National Certificate in Education (NCE)	1	6.3%	2	6.3%	4	25.0%	7	10.9%
	Ordinary National Diploma (OND)	-	-	6	18.8%	-	-	6	9.4%
	Secondary School Certificate	6	37.5%	15	46.9%	5	31.3%	26	40.6%
	First School Leaving Certificate	2	12.5%	2	6.3%	2	12.5%	6	9.4%
	None	2	12.5%	4	12.5%	1	6.3%	7	10.9%
	Total	**16**	**100.0%**	**32**	**100.0%**	**16**	**100.0%**	**64**	**100.0%**

Table 3-12 Demographic attributes of the focus groups: Occupation

		Senate District							
		Kogi Central		Kogi East		Kogi West		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Occupation	Missing	2	12.5%	4	12.5%	2	12.5%	8	12.5%
	Job Seeker	-	-	2	6.3%	-	-	2	3.1%
	Civil Servant	1	6.3%	5	15.6%	1	6.3%	7	10.9%
	Driver	-	-	1	3.1%	-	-	1	1.6%
	Farmer	1	6.3%	10	31.3%	2	12.5%	13	20.3%
	Industry	2	12.5%	-	-	1	6.3%	3	4.7%
	Student	1	6.3%	3	9.4%	4	25.0%	8	12.5%
	Teacher	-	-	1	3.1%	3	18.8%	4	6.3%
	Trader/Business	9	56.3%	6	18.8%	3	18.8%	18	28.1%
	Total	**16**	**100.0%**	**32**	**100.0%**	**16**	**100.0%**	**64**	**100.0%**

Table 3-13 Demographic attributes of the focus groups: Income

		Kogi Central		Kogi East		Kogi West		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Monthly Income (₦)	Missing	-	-	9	28.1%	3	18.8%	12	18.8%
	< 25,000	12	75.0%	18	56.3%	7	43.8%	37	57.8%
	25,001 - 50,000	4	25.0%	5	15.6%	2	12.5%	11	17.2%
	50,001 - 75,000	-	-	-	-	1	6.3%	1	1.6%
	75,001 - 100,000	-	-	-	-	2	12.5%	2	3.1%
	> 100,000	-	-	-	-	1	6.3%	1	1.6%
	Total	**16**	**100.0%**	**32**	**100.0%**	**16**	**100.0%**	**64**	**100.0%**

3.4.4 The Groups' Conversations

A cardinal principle of mixed methods research designs (as elaborated in Section 3.1) is that both quantitative and qualitative strands address the same research aim, objectives and questions. Therefore, in this study, all the conversations/dialogues of the focus groups revolved around the aims and objectives of this study, outlined in Section 1.3. The essence of conducting group discussions in this study is to realize the immense benefits of mixed methods research designs, as extensively discussed in Section 3.1.2. Most importantly, the group discussions of this study are helpful in partly validating and/or corroborating as well as adding explanatory depth to the findings obtained from the spatial analytics of the secondary data. This derives from the explanatory sequential mixed methods research design in which quantitative data analysis is the primary and dominant medium of meeting research objectives (Morse, 2003; Creswell and Clark, 2018a; McBride *et al.*, 2019, p. 699; Meixner and Hathcoat, 2019, p. 63). Consequently, after spatial analytics and statistical analysis of quantitative secondary data, it was necessary to consider a qualitative perspective. In this way, this thesis achieves a holistic and balanced understanding of problems of PHC accessibility in the study area, from both objective and subjective perspectives. To this end, the following questions were discussed in the group conversations:

1. What are the healthcare needs of this community?
2. By narrating a recent experience, how do you go about obtaining healthcare whenever a need arises?
3. What types of healthcare services do you prefer and what are your reasons?
4. In what ways can relevant authorities assist you in ameliorating your healthcare difficulties?

These questions, as well as possible follow-up questions, were contained in the discussion guide for this study, which was used by the facilitator/moderator of the group discussions (see Appendix C.7.5 for the discussion guide, page 437). These questions were used in order to ensure that the group conversations align with the objectives of this study. For instance, qualitative data from question 1 provides further understanding of the perceived healthcare needs in the study area. This provides subjective perspectives on the second objective of this thesis while simultaneously meeting the fourth research objective. Qualitative data from question 2 provides further insights on multiple objectives of this study, especially the third research objective. Depending on the nature of experiences narrated, information on perceived access to essential healthcare services can be gleaned from question 2. Question 3 is useful in obtaining qualitative data for analyzing the extent to which potential healthcare services would be acceptable to or compatible with the study area population.

All the fieldwork sites were rural areas. Therefore, group discussions were conducted in the native languages of the various study sites, with some use of pidgin English where preferred by the participants. In Nigeria, the majority of people in rural communities are more fluent in their native language than in other languages (including English). Even though many people in rural communities of north-central Nigeria may not understand or be fluent in formal English Language, a large majority can communicate in the pidgin English language. In addition, most people in rural communities belong in the same ethnic group; hence, their native language is a sufficient medium of conversation that is understood by all. For the foregoing reasons, the group discussions were mediated/facilitated by various indigenous field assistants who understand the native languages, being indigenes of their respective field sites. In places (like Kogi East) where the researcher understands the native language (i.e. Igala), being an indigene of this district, he served as a co-facilitator in the group discussions.

3.4.5 Ethical Considerations of Field Data Collection

Ethical approval was granted by the ethics review committee of the Faculty of Humanities and Social Sciences (HaSS), as shown in Appendix C.2.4. As part of the requirements for ethics approval, informed consent was obtained from all participants prior to participating in the group discussions. All participants were assured of their anonymity in reporting the findings of this thesis. Adequate measures were also taken to ensure that the study does not cause any form of harm to the participants as well as the researcher. The risk prevention strategies of this study are explained in the accompanying risk assessment form in Appendix C.1. Further details on the ethical considerations of this study are provided in Appendix C.2.

3.4.6 Qualitative Reflexivity and Positionality

There are various ways of understanding the concept of reflexivity (Finlay, 2002; Pillow, 2003). In order to account for potential bias, as well as the ongoing dynamics and power relations in the research process (especially the differences between an investigator and research participants), qualitative researchers are required to practice reflexivity as a way of making a study rigorous (Baxter and Eyles, 1997; Rose, 1997; Valentine, 2002; Finlay and Gough, 2008; Davies, 2012). Reflexivity is the "self-critical sympathetic introspection and the self-conscious analytical scrutiny of self as researcher" (England, 1994, p. 82). It is a thoughtful, self-aware analysis of the intersubjective dynamics between research participants and a researcher(s)

(Finlay and Gough, 2008). Though a personal introspection, reflexivity is the main strategy employed by qualitative researchers to undermine the critique of (post-)positivist scholars on the bias and subjectivity of qualitative studies (England, 1994; Davies, 2012).

Reflexivity is informed by positionality, which is a reflection of the position that a researcher has taken within a given study (Savin-Baden and Major, 2012; Manohar *et al.*, 2019). The concept of positionality requires researchers to analyze their individual 'situatedness' relative to a research process by acknowledging and accounting for the influence of their values, beliefs and views on the research process. Positionality, like worldviews, is situated socially, historically, politically, geographically; and culturally influenced by a myriad of factors including: education, religion, gender, sexuality, race, ethnicity, social class, age, linguistic tradition, and so on (Manohar *et al.*, 2019). Therefore, an exhaustive account of positionality, and by extension, reflexivity is neither possible nor necessary in the current study. Furthermore, as researchers, "we cannot … be aware of all the subconscious ways in which our assumptions shape our approaches to research" (Seale, 1999, p. 164). Despite these limitations, it is advisable to explicitly document a researcher's reflexive practice in qualitative studies, in order to improve their quality and rigour, thereby enhancing their trustworthiness and acceptability. Therefore, the remainder of this section is a limited reflexive practice for the current thesis.

The fieldwork of this study was organized by a male doctoral student, who is also a native of Kogi East Senatorial District of Kogi State, the study area. However, within this senatorial district, my specific LGA of origin is Ankpa, which is not one of the fieldwork sites. Even though I am of the same ethnicity and socio-cultural makeup with my research participants in the Kogi East senatorial district, I was mindful of the effects that this may have on the fieldwork. For all the group discussions conducted, I recruited competent field assistants who are indigenes of the various wards that had been selected for fieldwork. These field assistants were well-briefed on the details of the study as well as on the planned modalities for the fieldwork. A written guideline for the fieldwork, summarizing the planned rudiments, as well as the discussion/conversation guide, were also provided to each field assistant at the time of their recruitment (see Appendix C.7 for the fieldwork guide). This fieldwork guideline document therefore served as the terms of reference for the recruited field assistants. Each field assistant was adequately remunerated to ensure they did a thorough job in accordance with the guidelines. I know from first-hand experience that many of the residents in the study area are not socioeconomically well-off (as a result of the stark income inequality in Nigeria); therefore the possibility of obtaining financial gains from an activity is a potent motivator (even for civic activities like voting, which are often taken-for-granted in high-income countries). A total of four (4) field assistants were recruited for the entire study, with each field assistant organizing two (2) group discussions in the two selected communities in their respective wards. The role of my field assistants included: recruiting potential focus group participants, organizing the logistics of focus groups as well as moderating/facilitating the discussions. All these were done in consultation with myself and following my pre-specified guidelines (as outlined in Appendix C.7). I was present and participated in every group discussion of this study, during which I took up either a passive or active role depending on the necessities of a particular local context. In Nigeria, indigenes have privileged access to and security in their respective communities. Therefore, research assistants who were cultural insiders of the various wards would not only easily access their wards, but their insider status would also facilitate the overall conduct and interactions of the focus groups (Liamputtong, 2010; Suwankhong and Liamputtong, 2015). Cultural insiders share the same culture, language, social background and other commonalities with research participants; therefore, they are popularly considered to be important (assistant) researchers for ensuring fieldwork success (Ganga and Scott; Ergun and Erdemir, 2010; Liamputtong, 2010; Shariff, 2014; Suwankhong and Liamputtong, 2015; Manohar *et al.*, 2019).

The way a researcher is perceived by his/her participants, and conversely, is important to the success of all qualitative studies (Wegener, 2014; Berger, 2015; Hayfield and Huxley, 2015; Manohar *et al.*, 2019). In this regard, I acknowledge that my phenotype, as well as my socioeconomic and demographic profile, would have had multiple and varying influences on the practice of the groups' discussions. The theatrics of the focus groups were also mediated by the socioeconomic and demographic status and phenotype of my research assistant(s), as well as the research participants and context of each group discussion. Therefore, the interaction between the researcher, the research assistants and the participants in this study was an intersubjective reflexive process in which the self of the researcher(s) and the participants were co-constructed by multiple actors (and perspectives) and dialogues (Bryant, 2016). Since these group discussions were conducted in various localities with different cultures, a different field assistant was recruited for each ward. This makes the discussion of intersubjective reflexivity a dynamic and complicated activity for this study. For instance, being my senatorial district of nativity, the field assistants I recruited for the group discussions in Kogi East were persons that are my acquaintances. However, my field assistants in the other two senatorial districts were persons I was unfamiliar with, but individuals who had been recommended to me by my acquaintances. This is similar to the popular practice of snowballing in the recruitment of research participants for qualitative studies, wherein a researcher uses the social networks of initial informants to recruit other participants (in this case, other field assistants) (Noy, 2008; Yin, 2015, p. 95; Tracy, 2020b, p. 84). Furthermore, each participant of the various focus groups might have had a different (or distinct) perception of myself and my field assistants, depending on their individual circumstances. For instance, more educated group participants might understand the practice of academic research, while uneducated participants might be less acquainted with it. I also took up varying roles in the various group discussions conducted, in adapting to the peculiarities of the various focus group contexts. For instance, in some, I was more active and involved in organizing the discussion venues as well as moderating the conversations, while in others, I took a rather passive role (arranging my recording devices and taking snapshots while my research assistants moderated the discussions in their native languages). Overall, I was careful to maintain relational accountability to the research participants, research assistants and in the overall conduct of the fieldwork (Wilson, 2001; Diab and Wilson, 2008). The precepts of relational accountability underscore the need for researchers to be respectful and responsible in their qualitative fieldwork (Wilson, 2001; Rix *et al.*, 2014).

I generally had an approachable and friendly disposition in my various fieldwork contexts in order to connect with my participants and establish some rapport before the actual groups' conversations. This is necessary because in Nigeria, people are more inclined to interactions or conversations in convivial environments. As part of the pre-focus group information to participants, they were made to realize that the goal of the group discussion was to inform an ongoing academic research that I was conducting. However, in most of the focus group contexts, the participants seemed to think that I had some capability of causing some positive change to their situation, either directly or indirectly. This was especially so in contexts where participants had a limited understanding of the meaning or practice of academic research. I seem to have been perceived as a low-cadre government official or contractor, who had come to make some informal inquiries about the state of health-related affairs in their localities, and whose findings will be reported back to his bosses. With this perception, some participants seemed to think that my bosses were capable of improving the situation of things in their localities if they so wished. One implication of this reception is that a good number of participants were keen on saying what kinds of help they were expecting from the government even before I had asked.

My being perceived as a potential ‘contractor’ from the government as well as my being in the company of field assistants who were cultural insiders made me enjoy a favourable reception in all my fieldwork sites. Most participants were also willing to engage in the discussions. Many of these rural communities do not understand what it means to be an academic researcher; therefore, it is difficult to be ascribed such a profile no matter how hard a researcher tries. And even if the status of an academic researcher was achieved, it may not have had a better influence on the outcome of the group discussions than was achieved by my being perceived as a low-level ‘government contractor’ or official. In fact, my participants would have been reluctant to have a dialogue with a stranger who is not perceived to enjoy some form of practical or political influence over the issues being discussed. They may not be interested in spending one hour discussing their healthcare-related concerns with a cultural outsider, the researcher, whom they are sure cannot do anything about it. A similar sentiment was expressed by Fletcher (2014), who noted that white researchers are often distrusted by ethnic minority participants in cross-cultural studies because they (the white researchers) are considered as cultural outsiders. In this regard, one of Fletcher’s participants remarked: “For most you’re fine. Some probably won’t ever speak to you. They’re (the British Asians) happy to train and play alongside you, but they probably won’t sit and talk to you” (Fletcher, 2014, p. 252).

3.4.7 Limitations of the Fieldwork

Even though the basic socio-demographic characteristics of each focus group participant were collected (using a monitoring form), it was not possible to distinguish the responses of each participant. One way of achieving such distinction is for each participant to be assigned a code that tallies with their respective monitoring forms. Respondents could therefore be requested to mention their code before making contributions to the group discussions. However, this personal identification process will greatly disrupt the groups’ conversations. In this study, the researcher was interested in having group conversations that were as natural as possible. Furthermore, the concern with healthcare access was of a communal nature, as opposed to the concerns of individuals (as explained in Section 3.3.3.4). Since the unit of qualitative data analysis in this study is the focus group (instead of individual participants), there was no need to account for individual contributions to the group discussions. The next section considers the qualitative analysis of the data from the group discussions.

3.5 Method of Qualitative Data Analysis

For the analysis of qualitative data, this research project uses framework analysis (otherwise known as analytic hierarchy), which is an extension of and consequently, a more sophisticated variant of thematic analysis (Ritche and Spencer, 1994; Spencer *et al.*, 2003; Furber, 2010; Smith and Firth, 2011). It is explicitly concerned with generating practice- and policy-oriented findings, which makes it popular with many health and social researchers (Green and Thorogood, 2004b). It is therefore the choice method of qualitative data analysis for this study, which is extremely practice- and policy-oriented. In Table 3-14 is a schematic representation of the framework analysis process. Thematic analysis is able to produce rich and insightful understandings of phenomena regardless of theoretical and epistemological approaches (Braun and Clarke, 2006). It also enables the testing or extension of existing theories. However, thematic analysis has been criticized for fragmenting the phenomena being studied, lacking in transparency as well as being subjective in the development of themes, and lacking depth; consequently, the rigour of findings resulting from thematic analysis is difficult to judge (Attride-Stirling, 2001). Even though the initial stages of framework analysis share similar characteristics with thematic analysis, further stages of framework analysis help to overcome many of the downsides of thematic analysis. With framework analysis, not only is the process of qualitative data analysis transparent, but there is also great emphasis on the interlinkages between the stages of analysis (Pope *et al.*, 2000; Spencer *et al.*, 2003; Braun and Clarke, 2006). Within the interconnected stages of framework analysis, it is essential for a researcher to move back and forth over the qualitative data until a coherent result is achieved (Ritchie *et al.*, 2003; Spencer *et al.*, 2003). This process may also lead to the formation of a conceptual framework, further to the refinement of themes which result from the forward-backward inter-stage movement in framework analysis (Smith and Firth, 2011). The final stage of framework analysis, known as the mapping and interpretation stage, involves the use of tables and diagrams to explore the relationships between derived concepts and the classifications derived from them, as well as the associations between the concepts. This key tactic of the final stage is what moves framework analysis beyond a sophisticated thematic analysis (Green and Thorogood, 2004b).

Table 3-14 Overview of the framework analysis approach (Smith and Firth (2011), adapted from Spencer et al. (2003))

	Stages		
	Data management	**Descriptive accounts**	**Explanatory accounts**
Processes	• Becoming familiar with the data (reading and re-reading) • Identifying initial themes/ categories • Developing a coding index • Assigning data to the themes and categories in the coding index	• Summarising and synthesising the range and diversity of coded data by refining initial themes and categories • Identify association between the themes until the 'whole picture' emerges • Developing more abstract concepts	• Developing associations/ patterns within concepts and themes • Reflecting back on the original data and analytical stages in order to ensure participant accounts are accurately presented thereby reducing the possibility of misinterpretation • Interpreting and explaining the concepts and themes • Seeking wider application of concepts and themes
	← **Continuum** →		

Further rationales for choosing framework analysis for the qualitative data analysis of this study abound (Ritchie *et al.*, 2003; Spencer *et al.*, 2003). In summary, researchers' interpretations of participants' experiences and perspectives are made transparent with framework analysis. From available descriptive qualitative data, framework analysis enables a researcher to consider various aspects of the phenomena being studied. Transiting from the development of descriptive to interpretive accounts is well guided by the process of multi-stage forward-backward movements across the interconnected stages of framework analysis. This makes framework analysis well suited for inexperienced qualitative data analysts, enabling novices to overcome the daunting and bewildering task of transiting from data management/description to the development of deep analyses that are sufficient for answering their research questions (Smith and Firth, 2011). Unlike the grounded theory method, whose main goal is to 'discover theory from data' (i.e. inductive), while providing deep analysis of qualitative data, the goal of framework analysis is the generation of policy- and practice-orientated findings. With the latter being the overall goal of this doctoral thesis, as well as the qualitative strand of this chapter, it is therefore apparent that framework analysis is extremely well suited for this study; hence its adoption as the choice qualitative analysis method. In this vein, several studies on healthcare access have therefore used framework analysis (Neale *et al.*, 2008; George *et al.*, 2014; Bradbury-Jones *et al.*, 2015; Clifton *et al.*, 2016; Dowrick *et al.*, 2016; Evans *et al.*, 2016; Self *et al.*, 2018).

In order to implement framework analysis in this study, focus group data were carefully translated and transcribed in English Language, while maintaining the integrity of the conversations. To minimize loss of meaning during translation, for each group discussion, two transcriptions were produced by different translators. In addition to ensuring that there was no loss of meaning in translations, this also enhanced the quality and validity of the transcripts (Silverman, 2017). It assures that every comment of the group participants was likely to have been captured by both transcribers of each group discussion. The transcription of group discussions was tricky because there were times when multiple respondents were providing various responses simultaneously. The transcripts of group discussions were then imported into the NVivo 12 Qualitative Data Analysis Software (QDAS), which facilitates qualitative data coding and further analysis (and interpretation) (Woolf and Silver, 2017; Jackson and Bazeley, 2019), via the framework analysis process depicted in Table 3-14.

In performing framework analysis, the qualitative data coding process of the group discussion transcripts involved both deductive and inductive approaches, following standard precepts (Saldana, 2012; Tracy, 2020a). Consequently, both predefined and emergent themes and theoretical constructs were identified and coded in NVivo (Kaiser *et al.*, 2019). The unit of analysis was the focus group; therefore, there was no attempt to distinguish the responses provided by each respondent (Ritchie *et al.*, 2003). The framework analysis was, however, cognizant of the three senatorial districts in the study area in order to explore and explain potential disparities and similarities in the perceptions and experiences of healthcare access between the three main socio-cultural groups in the study area.

Instead of being guided by just one conceptual framework, the framework analysis of this thesis is informed by a body of literature as well as a corpus of theoretical frameworks that are found to be relevant to the various aspects of this thesis. In studies wherein highly varied themes are covered, it is not uncommon for qualitative analysis to be informed by multiple theoretical frameworks (Neale *et al.*, 2008; Jones *et al.*, 2016; Herbec *et al.*, 2018; Osei-Frimpong *et al.*, 2018; Norman *et al.*, 2019; Torres-Pereda *et al.*, 2019). Similarly, some studies also draw on a body of relevant literature for their qualitative data analysis (Lovelock and Martin, 2016; Liverani *et al.*, 2017; Sychareun *et al.*, 2018). These eclectic approaches are helpful in liberating a researcher from the constrictions of a single theoretical framework.

In this light, the main analytical tool for explicating perceived accessibility in this thesis is the 'three-delays model' (Thaddeus and Maine, 1994), because unlike other competing frameworks, it is sensitive to both perceived healthcare need and accessibility with adequate attentiveness to spatial and aspatial aspects as well as temporal/procedural facets of care-seeking or accessibility (Myers *et al.*, 2015), as illustrated in Figure 7-1. To provide deep insights on facets of perceived healthcare need, the 'three-delays model' is complemented by common-sense models or cognitive representations of illness (Martin *et al.*, 2003, p. 206; Benyamini, 2013, p. 284; Sarafino *et al.*, 2015, p. 232). Furthermore, to adequately account for multiscale contextual effects on perceptions and experiences of accessibility in the study area, the conceptual model of Cabieses and Bird (2014) also complements the 'three-delays model' in this thesis. Even though some discussions of conceptual frameworks are featured in Section 2.3.2, there is a return to further discussions of relevant concepts and constructs in Chapter 7, in light of the qualitative analysis of this thesis. The same chapter reflects on a myriad of qualitative theoretical dimensions while analyzing the qualitative data, with a view to eliciting relevant theoretical insights and understandings relevant to subjective aspects of spatial accessibility. The next section summarizes the main points of this chapter in highlighting some of the main methodological strengths and advances of the current thesis.

3.6 Summary of Methodology and Advances

This study employs an explanatory sequential mixed methods research design, as illustrated in Figure 3-7. In explanatory sequential mixed methods designs, the collection and analysis of quantitative data is the main medium of meeting research objectives and/or answering research questions. This is, however, followed by qualitative data collection and analysis in order to add depth to the explanations of findings from the quantitative data analysis as well as provide relevant corroboration. Hence, this study collects and analyzes quantitative/spatial data, which informs the collection and analysis of relevant qualitative data. In this way, quantitative and qualitative data types complement each other in meeting research objectives by helping to offset their individual weaknesses. The explanatory sequential mixed methods design in this research project is considered a special type that provides explicitly spatial results. Hence it can be referred to as a Spatial Mixed Methods Research (SMMR) design. This derives from the use of a corpus of sophisticated spatial analytics in contrast to the generic statistical analysis employed by most conventional mixed methods research designs.

Figure 3-7 Explanatory Sequential Mixed Methods Research Design (Creswell and Clark, 2018b, p. 189).

Concerns with zone designs are well established in geographic literature and are pervasive (Zhao and Exeter, 2016). These problems are more striking in developing contexts (like Nigeria) where extant zoning systems seem to have been arbitrarily created, are not fine-grained and are obsolete. They are therefore not suitable for equity-sensitive socio-spatial analyses of relevant human-social phenomena, such as the spatial accessibility of PHC services in the current study. At the time of data collection for this research project (2018), there are no small-area (ward-level) geographies in the study area, Kogi State. Wards are the smallest administrative (or data aggregation) zones in Nigeria; however, these extant wards are only available as gazetteers in Kogi State (as well as in most states of Nigeria). These ward gazetteers are therefore not mappable because there are no authoritative polygonal zones associated with them. This data dearth has hitherto hindered the possibility of performing robust small-area spatial analytics for the study area, such as the current study. Consequently, a prerequisite analytical step of this doctoral project is the automated creation of an optimized small-area analytical zoning system for the study area. This is accomplished with the use of the AZTool software (Ralphs and Ang, 2009; Cockings, 2013). In addition to providing an appropriate spatial scale for the analysis of primary healthcare services in the study area, optimized small-area analytical zoning systems minimize many of the pitfalls of using zonal data for spatial analytics, especially the Modifiable Areal Unit Problem (MAUP), ecological fallacy, aggregation bias and small population problems (Burden and Steel, 2016a, p. 2; Johnston and Sidaway, 2016b, p. 175). This is a necessary analytical foundation that enables the implementation of further analytical methods necessary for meeting further research objectives of this thesis.

Most existing implementations of automated designs of small-area analytical zoning systems have been in high-income countries (HICs) and have used pre-existing zones as Building Block Areas (BBAs). These BBAs (or basic units) are extant fine zones (such as Output Areas in the UK or Census Blocks of the USA) that are available in such contexts; however, among other things, these fine BBAs are not available in most LMICs, including the study area. Therefore, (to the researcher's knowledge), this study is the first to bypass these data scarcity problem by deriving and populating BBAs from first principles, using unconventional gridded demographic datasets[35] (particularly WorldPop grids). This is also the first automated small-area zoning system to be created in Nigeria. Among other things, this study is therefore innovative in that it extends the frontiers of knowledge on automated zone design methodologies by enabling the application of these methods in data-scarce countries like Nigeria, drawing upon unconventional datasets.

In order to analyze potential spatial access to primary healthcare services in the study area, there is a need for small-area estimates of healthcare needs. Spatial Microsimulation is the only explicitly geographical method of small-area estimation (Rahman and Harding, 2017, p. 16). Other small-area estimation methods are statistical models; therefore, they are not as robust as spatial microsimulation for spatial analytics. In this study, spatial microsimulation is used for the small-area estimation of standard SDG-related multivariate indicators of healthcare needs. It also enables the disaggregation/decompositions of derived spatial accessibility indices according to relevant socioeconomic and demographic stratifiers (as well as the potential computation of relevant indices of inequalities). Existing works on small-area estimation with spatial microsimulation are not only very few but have also been mostly conducted in HICs. These studies rely on the use of available small-area zoning systems (from censuses) as spatial constraints. Such small-area zoning systems are not available in LMICs; therefore, to the best of the researcher's knowledge, this is the first study to implement spatial microsimulation modelling for the estimation of standard health-related indicators for bespoke (optimized) small-area zones.

In health geography, variants of the floating catchment area methods are amongst the most adept for small-area analysis of spatial accessibility. This study implements a sophisticated variant of the two-step floating catchment area (2SFCA) analysis to comprehensively depict small-area patterns of spatial accessibility in the study area. This bespoke spatial accessibility algorithm is called an ONN-G2SFCA method, which features considerable advantages over other variants of the 2SFCA methods. Travel time (by '*okada*'[36]) on actual transportation

[35] Raster datasets (such as gridded demographic data) are not typically used for automated zone designs, because this methodology requires polygon data as inputs (i.e. BBA). The implication is that raster datasets has to undergo extensive and rigorous pre-processing operations to make them amenable as inputs for the zone design optimizations in this study.

[36] An 'o*kada'* is a smallish motorcycle used for commercial transportation in Nigeria.

routes is the impedance variable between healthcare demand and supply points. The enhancement features a gaussian generalized distance-decay function (which uses a stable coefficient). Dynamic catchment area sizes are also incorporated, in ensuring that each potential demand point considers an equal number of service supply points (McGrail and Humphreys, 2014). This helps to account for rural-urban differences, such that the catchment sizes for rural areas are larger than those of urban areas because of variations in the density of service availability in these two settlement types (Luo and Whippo, 2012). Furthermore, research shows that rural dwellers are more willing to cover longer distances in seeking healthcare than urban dwellers (Arcury *et al.*, 2005; McGrail and Humphreys, 2009b). Spatial accessibility analysis requires rich spatial data at small-area spatial scale, which are often unavailable in most LMICs. Consequently, most existing robust analysis of small-area spatial accessibility have been conducted in HICs using extant small-area zones of censuses. In analyzing small-area accessibility of primary healthcare services, this is likely the first study in LMIC context to make improvements in all the aspects discussed in Section 3.3.3 (at least in Nigeria).

Finally, most studies of spatial accessibility are exclusively quantitative, relying mainly on the power of contemporary GIS software. Consequently, without the direct discursive participation of research subjects, they fall short in the downsides of quantitative methods and spatial analytics by disregarding the experiences, feeling, perspectives and desires of their research subjects (Pickles, 1995; Cope and Elwood, 2009, pp. 16, 25; Aitken and Kwan, 2010; Johnston and Sidaway, 2016b, p. 159). Thus, they fail to realize that people's perception of access are as valid as objective measures (derived from quantitative methods), not least because a lot of perceptual processes go into health-seeking behaviours from the outset (Fortney *et al.*, 2011). These perceived aspects are discussed by Levesque *et al.* (2013), as highlighted in Figure 2-4. The need for qualitative research on spatial access to be informed by findings from quantitative analysis is a contemporary recommendation, which warrants the SMMR design of this study (Rosenberg, 2016). In promoting an understanding of the qualitative elements that inform spatial access (Ricketts, 2009, p. 523), qualitative analysis helps to address what remains missing from most studies of healthcare geographies – a deeper understanding of what lack of access to care means to the everyday lives of people (Rosenberg, 2014, p. 5). By discursively considering qualitative dimensions, this study therefore improves on existing works on spatial accessibility while focusing on places of extreme lack of access to primary healthcare in the study area. In this process, it not only reflects on the framework and concept of social exclusion but by so doing, also seeks to empower and emancipate these extremely deprived people by giving them a voice as well as serving as an advocate (Gesler and Kearns, 2002, p. 159; Commission on Social Determinants of Health (CSDH), 2008). The findings from the foregoing methodological discussions are presented and discussed in Chapters 4 to 7, starting with the optimized small-area analytical zoning system developed for the study area in Chapter 4.

Chapter 4. Automated Creation of Optimized Small-Area Analytical Zones in Nigeria: Zone Design Experiments with Kogi State.

4.1 Background

This chapter is an empirical response to the methodological discussions in Section 3.3.1 in which it is well-established that zoning concerns are pervasive in geographical literature (Zhao and Exeter, 2016), especially in studies that border on spatial analysis of human-social phenomena, such as healthcare accessibility of the current project. This chapter helps to structure further spatial analyses of this research project in order to adequately account for the match between underlying concepts and the relevant spatial units of analysis. This is necessary for grounding understandings of small-areas (or neighbourhoods) and spatial disparities in more appropriate empirical measures of socio-spatial accessibility. Using the optimized small-area zoning system resulting from this chapter enables valid statistical inferences to be derived from this research project (Alvanides and Openshaw, 1999; Flowerdew *et al.*, 2008). It serves as a way of minimizing aggregation bias, small population problems, UGCoP and the MAUP by controlling for spurious/extraneous spatial effects of areal data (Duque *et al.*, 2012, p. 28). The aggregation of Building Block Areas (BBAs) into relatively homogeneous zones (in terms of socioeconomic and demographic characteristics) is also a first step in optimizing the spatial reconfiguration of healthcare services in the study area.

To this end, extant zoning systems in the study area are conceptually and empirically interrogated and problematized at two spatial scales, Wards and LGAs. In their place, synthetic optimized zoning systems are automatically created from scratch using an automatic zone design algorithm. Thus, in contrast to extant zoning systems, analytical (or functional) regions that are optimized for further spatial analytics of this thesis are developed in this chapter. In addition to meeting the standard zone design criteria outlined in Section 3.3.1.3, as well as minimizing or bypassing the pitfalls/downsides of extant zoning systems discussed in Section 3.3.1.2, the output of this chapter also minimizes aggregation errors of the points of healthcare needs (i.e. potential demand points) used in the analysis of neighbourhood/aggregate spatial accessibility in this study (Hewko *et al.*, 2002; Langford and Higgs, 2006; Apparicio *et al.*, 2008, 2017). The synthetic wards developed in this chapter can also be used to develop optimized service districts, specifically healthcare districts, appropriate for planning ward-level healthcare facilities like Primary Healthcare Centres in the study area. Service districts demarcate for healthcare personnel areas of responsibility for homecare visits or to define which facility should be visited by each inhabitant in order to obtain healthcare services like preventive medical examinations (including vaccines and ANC).

Analytical zoning systems (or functional regions) are defined according to relevant analytical requirements, characterized by geographical criteria (like shape, areal size and contiguity) and/or socioeconomic criteria (like population homogeneity) (Duque *et al.*, 2007, p. 2). Thus, many authors recommend the design of bespoke zoning systems that are well-suited for application-specific analysis purposes (Alvanides and Openshaw, 1999). Even though there are limitless ways of grouping BBAs into synthetic zones (Flowerdew *et al.*, 2008, p. 1244), this chapter considers optimized solutions based on the specified zone design criteria for this study, derived by a robust zone design algorithm. In Sections 4.3.1 and 4.3.2, optimized zone designs that approximate the existing zoning system of the study area are developed in order to unravel potential structural inefficiencies and inequities in the study area. In a subsequent section, optimized small-area zoning systems tailored for the small-area spatial accessibility and equity requirements of this research project are developed as a basis for further analysis in subsequent chapters. As explained in Section 3.3.1, this chapter therefore makes empirical contributions to the international literature on automated zone design in LMICs (George *et al.*, 1997; Guo, 2008; Guo and Wang, 2011; Spielman and Logan, 2013; Zhao and Exeter, 2016).

This chapter is particularly invaluable to data-scarce contexts of the global south (like Nigeria), which complicate the application of such methods to the extent that there is almost a non-existence of similar studies in these contexts. In this regard, this study also features innovative exploitation of unconventional data types (i.e. gridded demographic data) in a developing context where the dire paucity of relevant spatial data greatly limits socio-spatial analyses at small-area scales (Mohammed *et al.*, 2012; Tomintz and García-Barrios, 2014). It fills important empirical knowledge gaps by helping to answer the questions: (1) what are the conceptual and practical problems with the existing zoning system in the study area? (2) In data-scarce contexts of LMICs (like Nigeria), how can optimized small-area zoning systems for spatial analysis be derived? (3) How can researchers derive a realistic network of potential health service supply sites that are irredundant? (4) What is the optimum number and locations of aggregated demand points for healthcare service planning? In meeting the first objective of this research project, the foregoing questions are answered in the remainder of this chapter which implements the Automated Zoning Procedure (AZP) introduced in Section 3.3.1.

4.2 Materials and Methods for Automated Zone Design

This section starts by explaining the datasets used for the automated zone design operation of this thesis. Thereafter, the specific procedures for developing the optimized small-area analytical zoning system for this study are explained. The obtained results are presented and discussed in Section 4.3 with a view to demonstrating the benefits of automated zone designs over the readily-available zoning systems in Nigeria.

4.2.1 Data Types and Sources

Whereas all the secondary datasets used in this thesis are outlined in Section 3.2, this section discusses the particular datasets used in this chapter. The main dataset used for the automated zone design operations of this Chapter is the 1 km^2 gridded demographic dataset obtained from the WorldPop Project (WorldPop Project, 2016; Tatem, 2017). Others are: (1) the list/gazetteer of administrative zones for Nigeria, obtained from the website of the Independent National Electoral Commission (INEC) of Nigeria[37], and (2) the ward geographies for select Local Government Areas (LGAs) prepared by an NGO, eHealth Africa, obtained from the Vaccination Tracking System (VTS) website[38].

Spatial demographic data from WorldPop Project is the most detailed and up-to-date of freely available options, such as – LandScan (Dobson *et al.*, 2000), Global Rural-Urban Mapping Project (GRUMP) (Balk *et al.*, 2006; Center for International Earth Science Information Network (CIESIN) *et al.*, 2011), Gridded Population of the World, version 4 (GPWv4) (Doxsey-Whitfield *et al.*, 2015; Center for International Earth Science Information Network (CIESIN), 2018) and the Global Human Settlement Layers (GHSL) (Freire *et al.*, 2016; Florczyk *et al.*, 2019; Pesaresi *et al.*, 2019; Schiavina *et al.*, 2019). The goal of the project is to overcome the paucity and poor quality of population data in LMICs of the world by creating databases of human population that are useful for epidemic modelling, disease burden estimation, accessibility modelling, poverty mapping, disaster management, resource allocation, transport and city planning, environmental impact assessment amongst others (Tatem, 2017). To create these spatial population data, the WorldPop project combines a plethora of open source geospatial datasets in a flexible regression framework to reallocate contemporary aggregated spatial population count data (Tatem *et al.*, 2013; Stevens *et al.*, 2015; Pezzulo *et*

[37] https://www.inecnigeria.org/wp-content/uploads/2019/02/RA-LGA-ANALYSIS-NATIONWIDE.pdf (assessed by August, 2019)

[38] http://vts.eocng.org/geometry_export/ (assessed by August, 2019)

al., 2017). With relevant statistical assessments, the resultant population maps have been consistently found to be more accurate than other population/demographic data products as well as the simple rasterization of census data (Lloyd *et al.*, 2017). With some of their demographic grids having a spatial resolution of 100 meters, they also depict finer mapping details than other free data providers have produced at national scales. The methods for producing these gridded demographic data are extensively discussed elsewhere (Tatem *et al.*, 2007; Linard *et al.*, 2012; Gaughan *et al.*, 2013; Deville *et al.*, 2014; Alegana *et al.*, 2015; Stevens *et al.*, 2015).

Based on the foregoing, the accuracy, validity, reliability, credibility and trustworthiness of the WorldPop spatial demographic data are not dubious for the current study. A clear proof of this is that WorldPop data is used by a wide variety of government agencies (including 95% of the countries mapped by the project) as well as a plethora of reputable international organizations, foundations and agencies (WorldPop Project, 2019). Few known limitations of the WorldPop data, as outline by Lloyd *et al.* (2017, p. 14), are of negligible effect to this study. These include deficiencies of data sources from which they were created as well as potential inadequacies of their spatial resolution and the tendency of being outdated. From the WorldPop Project, the specific gridded demographic datasets used are:

- **Population** (disaggregated by sex by 5-year age grouping) for the year 2020 (produced in 2016)[39]: This estimates the number of females and males in each 5-year age group for every 1 square kilometre grid;
- **Poverty**[40]: This is an estimate of the proportion of people per 1 kilometre grid square living in poverty by the year 2010, defined by $1.25 a day and $2 a day threshold;
- **Contraceptive Use**[41]: This is an estimate of the proportion of women aged 15 – 49 years per 1 kilometre square grid that were using modern contraceptive methods in the year 2013;
- **Literacy**[42]: This is an estimate of the proportion of men and women aged 15 – 49 years per 1-kilometre square grid that were classed as literate in 2013;
- **Stunting**[43]: This is an estimate of the proportion of female and male children aged under 5 years, per 1-kilometre square grid that were classified as stunted in 2013.

[39] https://www.worldpop.org/geodata/summary?id=1276
[40] http://www.worldpop.org.uk/data/summary/?doi=10.5258/SOTON/WP00200
[41] http://www.worldpop.org.uk/data/summary/?doi=10.5258/SOTON/WP00198
[42] https://www.worldpop.org/doi/10.5258/SOTON/WP00199
[43] https://www.worldpop.org/doi/10.5258/SOTON/WP00201

These spatial demographic data are used to calculate the population count per Building Block Area (BBA) disaggregated by sex and 5-year age groupings. Using these data, other relevant demographic attributes are also estimated per BBA, such as: poverty, contraceptive use, literacy and stunting. The procedure for using these gridded demographic data is detailed in Section 4.2.2.

The gazetteer (i.e. tabular list) of administrative zones, especially wards for Kogi State, was downloaded from INEC's website (INEC Nigeria, 2019b). INEC is Nigeria's constitutional agency responsible for conducting national elections (INEC Nigeria, 2019a). As wards are political districts, INEC is an authoritative data source of national administrative boundaries. Therefore, the ward gazetteer (as well as other administrative data) obtained from INEC are reliable, valid and trustworthy. Thus, they are very fit for use in this research project. This helped to determine the number of Wards and LGAs per senatorial district in the study area, necessary for comparing the extant zoning system with a simulated optimized replica. In other words, the cardinal question in this regard is: maintaining the total number of wards in the study area, Kogi State, what is the optimal number (and zoning system) of wards that should accrue to each LGA (and senatorial district)?

By the year 2018 when relevant spatial data were collected from secondary sources for this doctoral research project, authoritative administrative boundary data of Nigeria were available only at the State and LGA levels for the entire country (from the National Population Commission). An NGO, eHealth Africa, fills this data gap by producing ward-level administrative zones for some states. This data was available for ten (10) select states in northern Nigeria, which did not include the study area, Kogi State. At the time of this research project, ward-level administrative data (as polygons) from eHealth Africa were available for only three (3) LGAs in the study area, namely: Dekina, Ibaji and Kabba. Therefore, the extant ward geographies of these select LGAs are helpful in comparing the existing ward zoning system with the simulated optimized replica discussed in Section 4.3.1.

4.2.2 Methods of Data Analyses

The AZTool software which is one of the most robust tools for implementing automated zone designs is used in the current study (Ralphs and Ang, 2009; Cockings, 2013). It was downloaded from its official website http://www.geodata.soton.ac.uk/software/AZTool/. Other relevant software tools are highlighted in Appendix A.3.1. The procedure of using the AZTool to develop optimized small-area geographies for any context can be divided into three stages (Martin, 2014, p. 109). In this study, these are:

1. **The design and attribution of Building Block Areas (BBAs):** This is primarily a GIS operation in which a tessellation of hexagonal polygons is created over the study area and then spatial demographic grids from the WorldPop project are used to populate the attributes of each BBA. Stage 2 and 3 that follow are part of the actual Automated Zone Design (AZD) procedure.
2. **The application of hard zoning constraints:** User-specified criteria that must always be met are referred to as ***hard constraints***. For example, all optimized small-areas should be made up of contiguous BBAs, and no island small-area is allowed. Furthermore, all resulting small-areas should be above and/or below a minimum and maximum population threshold respectively. The higher-level zones (and other physical boundaries, like major rivers) within which small-areas must be contained (and/or must not cross) are also hard constraints.
3. **The application of soft zoning constraints:** constraints which may be compromised and traded-off and for which a perfect solution will not be available are known as ***soft constraints***. These include equality of population size, the compactness of the shape of the optimized small-areas, as well as the social and demographic homogeneity within each optimized small-area. The allowable compromises in these soft constraints are controlled with user-specified weights. These user-specified weights are often determined based on an analysts preferences or by experimentation (Martin, 2000, p. 110).

The processing workflow for performing the analyses in this chapter are presented in Figure 4-1. ArcGIS 10.5 Desktop was used to generate a hexagonal tessellation of 1 km^2 for the study area, which serves as the BBAs for the process of automated zone design of this chapter. The 'Generate Tessellation' tool is the main ArcGIS tool used for this operation; however, this is coupled into a customized ArcGIS tool, which ensured that the generated hexagonal BBAs are constrained to the geometric boundary shape of the study area. Otherwise, the 'Generate Tessellation' tool produces a hexagonal tessellation for the minimum rectangular area that envelops the study area; thereby including places outside of the study area. The customized geoprocessing tool used in this study for creating the hexagonal tessellation of 1 km^2 BBAs (i.e. hexabins) for the study area is shown in Figure 4-2 below[44]. The population and other demographic attributes of both the hexagonal BBAs and the extant administrative geographies of the study area were populated from the WorldPop gridded population data. This is achieved with the aid of other bespoke ArcGIS geoprocessing models developed for this study, as shown in Figure 4-3 and Figure 4-4.

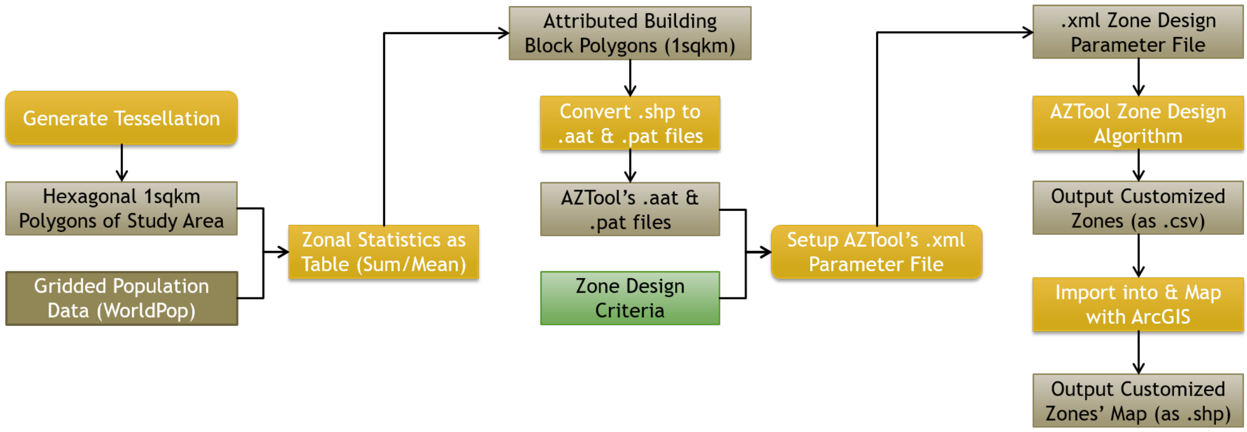


Figure 4-1 Workflow of the automated development of optimized small-area analytical zoning systems for the study area (Author, 2019)

[44] With the same ArcGIS Desktop, the python script of all the bespoke geoprocessing models featured in this thesis can be readily revealed if necessary.

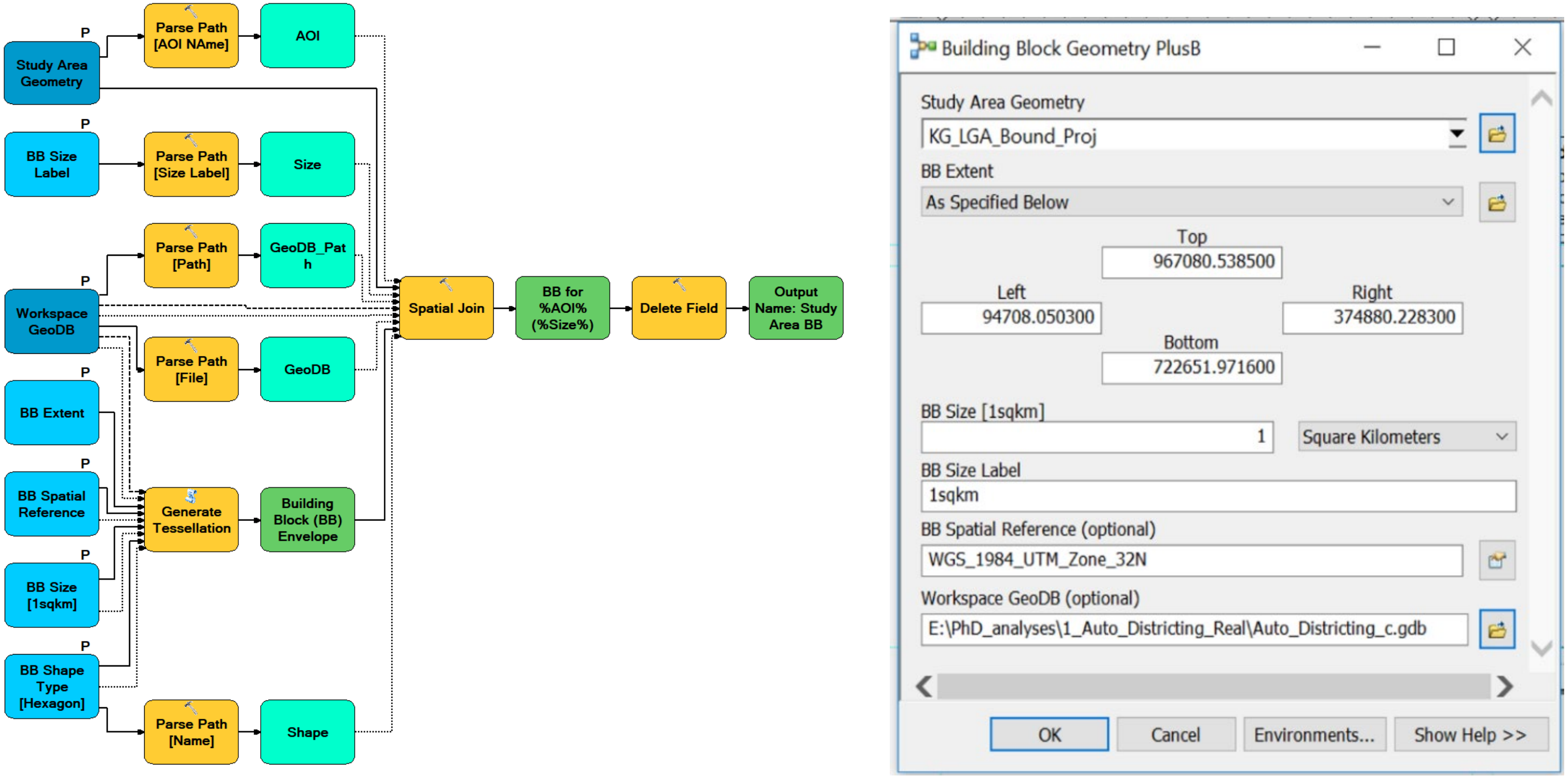


Figure 4-2 The ArcGIS geoprocessing workflow with the associated customized ArcTool for creating the hexagonal BBA for the study area (Author, 2019)

The AZTool algorithm is used to implement the design and automated creation of various versions of optimized zoning systems for the study area (Flowerdew *et al.*, 2008). The standard procedure for using the AZTool algorithm is followed in analyzing the existing zoning system as well as for creating optimized synthetic small-area zoning systems (Zhao and Exeter, 2016). First, the shapefiles of both the BBAs and the extant zoning system are converted to the format readable by the AZTool software, namely: the arc attribute table (.aat) and the polygon attribute table (.pat) (i.e. contiguity) formats. The 'AZT Importer', a software that accompanies the AZTool software, is used to convert shapefiles (.shp formats) to AAT and PAT files for use by the AZT algorithm. Using the AZTool Importer, the hexagonal BBA that was created and populated in the ArcGIS software environment was exported into the format for the AZTool. The AZTool software requires that a .xml file is configured with the requisite zone design criteria. The specific zone design criteria used to configure the .xml file for creating the various synthetic zoning systems of this study are presented in Table 4-1, Table 4-2 and Table 4-3, whereas the procedure for implementing these criteria in the AZTool software is illustrated in Figure 4-5.

In addition to outputting an optimized zoning system for a study area, the AZTool produces the following statistics:

- **Population**: minimum, maximum, mean, standard deviation
- **Zone Compactness** (i.e. the P2A metric introduced in Section 3.3.1.3): Minimum, Maximum, Mean, Standard Deviation
- **Zone Homogeneity** (i.e. the IAC metric introduced in Section 3.3.1.3): minimum, maximum, mean, standard deviation.

Therefore, the AZTool is also helpful for calculating the foregoing parameters for the extant zoning systems of the study area as well as for the optimized synthetic (small-area) zoning systems produced. Furthermore, these optimization metrics are also computed for each of the senatorial districts in the study area as well as for select LGAs. This makes it possible to explore the spatial variations in these zone design parameters for some of the lower-level geographies of the study area, as discussed in Sections 4.3.1 and 4.3.2.

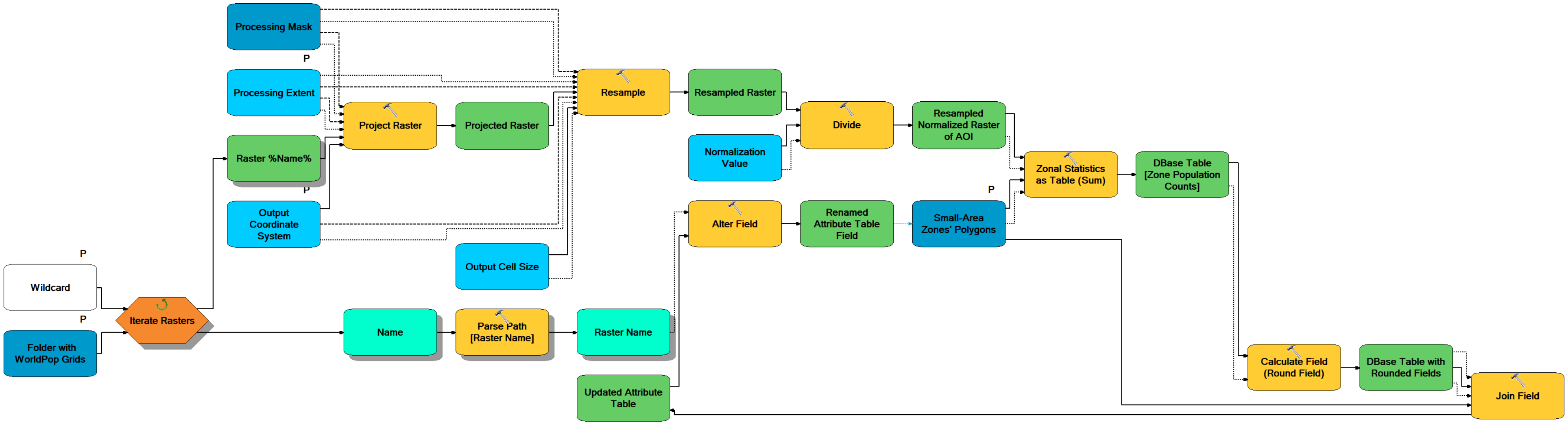


Figure 4-3 A bespoke ArcGIS geoprocessing model for recursively computing population count (by Age/Sex structure) from relevant 1km² WorldPop grids (held in a folder) (Author, 2019)

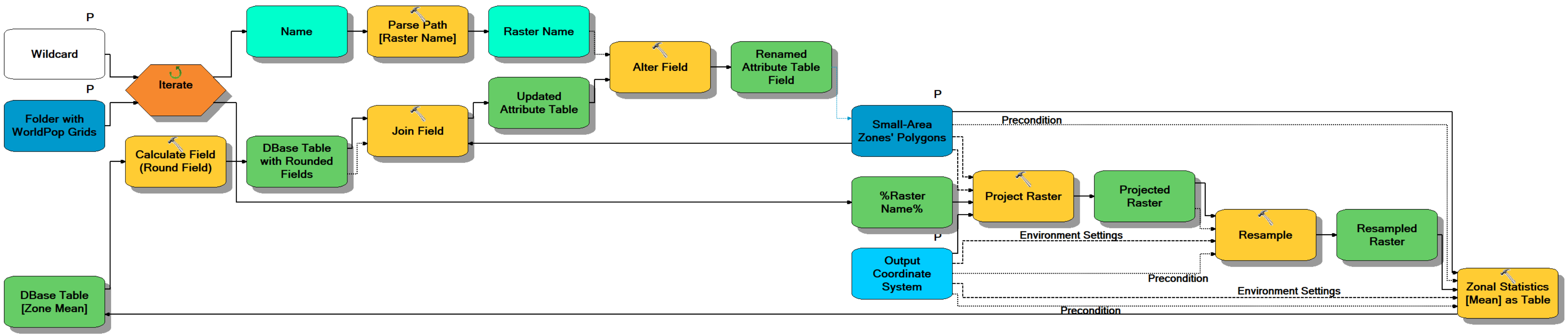


Figure 4-4 A bespoke ArcGIS geoprocessing model for recursively computing population attribute proportions (like illiteracy by sex, and poverty) from relevant 1 km² WorldPop Grids (held in a folder) (Author, 2019)

Table 4-1 Zone design criteria used for the automated creation of synthetic wards that emulate the number of extant wards in (parts of) the study area

Constraint/Criteria	**Emulating Extant Wards in 3 Select LGAs**				**Emulating Extant Wards in entire Study Area**			
	Value	**Weight (%)**	**Value**	**Weight (%)**	**Value**	**Weight (%)**	**Value**	**Weight (%)**
Minimum population threshold	False	-	False	-	False	-	False	-
Maximum population threshold	False	-	False	-	False	-	False	-
Target Population[a]	21315	100	21315	100	19958	100	19958	100
Target tolerance (%)	10	-	25	-	40	-	35	-
Zones Count based on Target Population	True	-	True	-	True	-	True	-
Respect Higher Region (True/False)	True: LGA	-	True: LGA	-	True: Senatorial Districts	-	True: Senatorial Districts	-
Homogeneity (IAC)	True	100	True	500	True	100	True	100
Compactness (P^2/A)[b]	True	200	True	1000	True	3500	True	1500
Resulting Zoning System	Figure 4-7C (and Table 4-7)[c]		Figure 4-7D (and Table 4-8)[d]		Figure 4-8A (and Table 4-10)[e]		Figure 4-8B (and Table 4-10)[f]	

[a] This parameter makes the zone design algorithm to produce the desired/target number of zones in instances where optimized zoning systems are expected to emulate the number of extant zones with a view to making comparisons.

[b] Shape compactness consistently receives more weighting than all other zoning criteria throughout this research, because it is the only soft criteria that has a direct positive effect on accessibility applications of zoning systems, which is a core objective of this study (please see Section 3.3.1.3 for further details on this).

[c] Emulating wards in the 3 select LGAs, optimized for population balance

[d] Emulating wards in the 3 select LGAs, optimized for shape compactness and population homogeneity

[e] Synthetic wards emulating the number of wards in the entire study area, optimized for shape compactness

[f] Synthetic wards emulating the number of wards in the entire study area, with no significant prioritization of any zone design criteria

Table 4-2 Zone design criteria used for the automated creation of synthetic LGAs that emulate the number of extant LGAs in the study area

Constraint/Criteria	**Synthetic LGA Zones from 1 km² Hexagons as BBAs**				**Synthetic LGA Zones from Synthetic Wards as BBAs**			
	Value	**Weight (%)**	**Value**	**Weight (%)**	**Value**	**Weight (%)**	**Value**	**Weight (%)**
Minimum population threshold	None	-	None	-	None	-	None	-
Maximum population threshold	None	-	None	-	None	-	None	-
Target Mean Population	227,142	100	227,142	100	227,142	100	227142	100
Target tolerance (%)	10	-	15	-	10	-	15	-
Zones Count based on Target Population	True	-	True	-	True	-	True	-
Respect Higher Region (True/False)	Senatorial Districts + Niger-Benue Trough	-	True: Senatorial Districts	-	True: Senatorial Districts	-	True: Senatorial Districts	-
Homogeneity (IAC)	True	100	True	500	True	100	True	500
Compactness (P^2/A)	True	3500	True	1700	True	3500	True	1700
Resulting Zoning System	Figure 4-9A (and Table 4-14)		Figure 4-9B (and Table 4-15)		Figure 4-10C (and Table 4-16)[g] and Figure 4-10D (and Table 4-17)[h]		Figure 4-10E (and Table 4-18)[i] and Figure 4-10F (and Table 4-19)[j]	

[g] These criteria were implemented using version A of the synthetic wards as BBAs, see Footnote e, Figure 4-8A and Table 4-10
[h] These criteria were implemented using version B of the synthetic wards as BBAs, see Footnote f, Figure 4-8B and Table 4-11
[i] These criteria were implemented using version A of the synthetic wards as BBAs, see Footnote e, Figure 4-8A and Table 4-10
[j] These criteria were implemented using version B of the synthetic wards as BBAs, see Footnote f, Figure 4-8B and Table 4-11

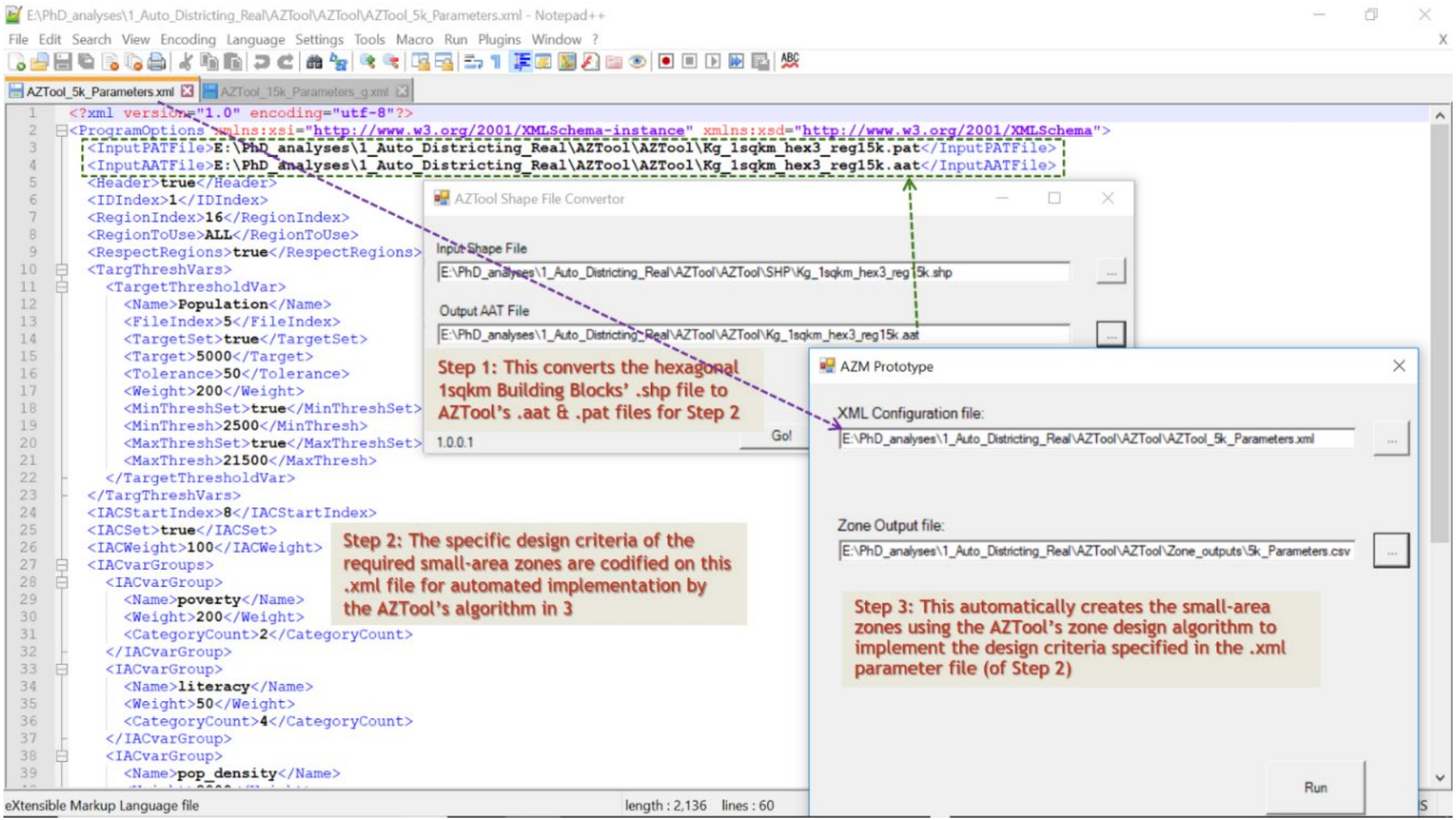


Figure 4-5 The AZTool software interface illustrating the steps involved in the automated zone design process (Author, 2019).

For each of the extant zoning system analyzed, optimized synthetic alternatives are simulated, which essentially emulate extant number of zones in the study area. All the simulated optimized synthetic zoning systems respect the extant senatorial district boundaries as well as the natural demarcations of the two major rivers in the study area, Rivers Niger and Benue. Following these, two spatial scales of optimized bespoke small-area analytical zoning systems are created for the study area, by which the small-area analyses of variations in the spatial accessibility of primary healthcare services are analyzed. Of these, the higher-level geography targets an optimum population of 15,000 persons (with a minimum of 10,000 persons per zone). These are operationally called synthetic wards. Nested within this is a lower level geography that targets an optimum population of 5,000 persons (with a minimum population of 2,500 persons per zone). This is operationally called synthetic neighbourhoods. The target population of synthetic wards emulates the planned threshold population of Primary Healthcare (PHC) facilities in the study area, which corresponds with the expected average population of extant wards (NPHCDA, 2012). Similarly, synthetic neighbourhoods emulate the expected population of neighbourhoods (or groups of villages) in Nigeria, which corresponds with the planned threshold population of Primary Health Clinics (NPHCDA, 2012).

The synthetic wards and neighbourhoods of this project do not respect the boundaries of the extant 'arbitrary' administrative zones in the study area. Being in themselves permeable, it is unnecessary for the developed synthetic analytical zoning system of this study to respect extant administrative boundaries because this will significantly undermine its optimality. Nevertheless, the natural barriers imposed by the two major rivers in the study area are respected since they also exert a significant effect on spatial accessibility, being reasonably impermeable[55]. Further details on the zone design criteria for the two levels of optimized synthetic small-area zoning systems of this study (i.e. synthetic wards and synthetic neighbourhoods) are presented in Table 4-3. The results of the automated zone design experiments explained in this section are presented and discussed in the remainder of this chapter.

[55] The two major rivers which are about 3km wide, can only be crossed by automobiles at 2 places where there are bridges. In few other places, there are boats and ferries which convey people across; however, this is not a popular medium for crossing these rivers.

Table 4-3 Zone design criteria used for the automated creation of the two scales of optimized synthetic small-area zoning systems for the study area, i.e. synthetic wards and synthetic neighbourhoods.

Constraint/Criteria	**Level 2: Synthetic Wards**		**Level 1: Synthetic Neighbourhoods**	
	Value	**Weight (%)**	**Value**	**Weight (%)**
Minimum population threshold	10,000	-	2500	-
Maximum population threshold	26,000	-	26,000	-
Target Mean Population	15,000	100	5,000	100
Target tolerance (%)	20	-	20	-
Zones Count based on Target Population	False	-	False	-
Respect Higher Region (True/False)	True: Niger-Benue Trough	-	True: Level 2 + Niger-Benue Trough	-
Homogeneity (IAC)	Yes	100	Yes	100
Compactness (P^2/A)	Yes	20,000	Yes	20,000
Resulting Zoning System	Figure 4-11A, with Table 4-21		Figure 4-11B, with Table 4-21	

4.3 Results and Discussions

In this section, the statistics (and maps) obtained from relevant automated zone design operations are presented and discussed in the following order. First, extant wards are discussed and compared with their optimized synthetic variants. Second, extant LGAs are analyzed in comparison with their optimized synthetic variants. Third, the optimized small-area analytical zoning systems for this study are discussed with a view to elucidating their immense benefits over the extant zoning systems in the study area. All of these discussions mainly consider the three soft zoning optimization criteria of this study, namely: population balance and thresholds, shape or compactness and population homogeneity, introduced in Section 3.3.1.3. Before these, an overview of some key characteristics of the current zoning system is considered, with a focus on the senatorial districts, which are the main units of socio-cultural differentiation in this study. These are shown in Table 4-4 and Table 4-5, as well as Figure 4-6 that follows.

Table 4-4 The number of Wards and LGAs per senatorial district in Kogi State (Author, 2019)

Senatorial District	Population Estimate (Year 2020) (WorldPop Project, 2016)	Land Mass (km^2)	Population Density	Number of LGAs	Number of Wards
Kogi Central	1,366,100	3,149.72	433.72	5	57
Kogi East	2,106,693	13,602.95	154.87	9	97
Kogi West	1,297,569	12,264.06	105.80	7	85
Total	**4,770,362**	**29,017.27**	**164.40**	**21**	**239**

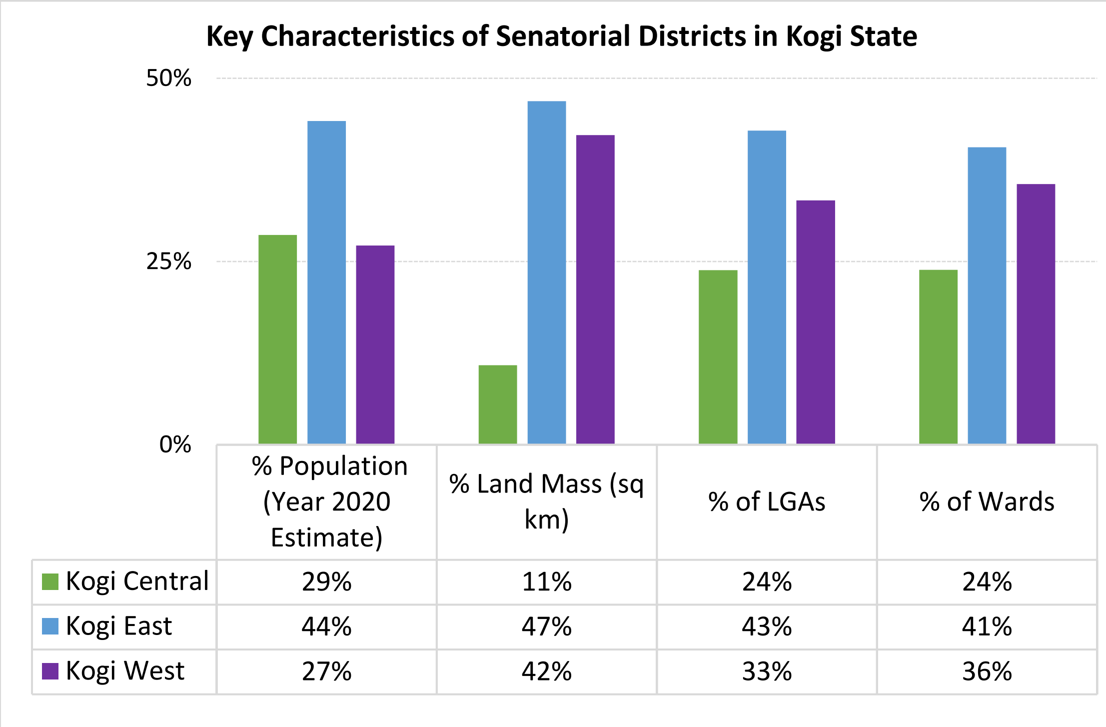


Figure 4-6 The proportion of population, land area, LGAs and Wards shared by the three senatorial districts in Kogi State

Table *4-5 The number of Wards per select LGA in the study area (Author, 2019)*

LGA	Population Estimate (Year 2020) (WorldPop Project, 2016)	Land Mass (km^2)	No. of Wards
Dekina	364,925	2,462.09	12
Ibaji	186,632	1,377.37	10
Kabba	215,796	2,707.24	14
Total	**767,353**	**6546.70**	**36**

From Table 4-4 and Figure 4-6, it can be seen that Kogi East is about half the population of the study area (44%), as well as being about twice the population of each of the other two senatorial districts. It also has about half (47%) of the land area of the state, with Kogi West having about 42%. As a result of the foregoing, Kogi Central, with relatively much less landmass (11%), has the highest population density that is about four times the population density of the other two senatorial districts. It is more cost-effective (and therefore cheaper) to provide public services that warrant a spatial dimension in areas of relatively high population density (Humphreys and Smith, 2009, p. 74; Burkey, 2012, p. 793). For example, the overall length of roads, or pipelines, or electric cables required to adequately service a densely populated area (per unit person) is much less than what is required to service the same population if they were to occupy a larger expanse of land. In a similar vein, stationary point-based public services like hospitals, schools, post offices or post boxes and prisons are more cost-effectively provided in densely populated areas than in sparsely populated areas. Consequently, accessibility of public services in densely populated regions tends to be better than sparsely populated regions. Not only is it easy for densely populated places to meet the threshold requirement for services (i.e. the number of persons near a service needed for patronage), these populations are also likely to cluster in close proximity to the provided service, thereby enhancing the likelihood of service utilization[56]. The foregoing partly explains the stark dichotomy in urban-rural accessibility, with urban areas (which are usually densely populated) being generally more accessible to public services than rural areas, which are often of sparse population density (Thomas, 2007; Peters and Gupta, 2009, p. 438).

As further chapters show, the implication of the foregoing considerations to this study is that healthcare deserts in Kogi Central tend to have better accessibility to primary healthcare services than the healthcare deserts in the other two senatorial districts. This is reinforced by the qualitative analysis in Chapter 7, which explores access-related experiences at healthcare deserts in the three senatorial districts. This is accentuated by the current policy and practice of the Nigerian government, which distributes public services (like healthcare facilities) based on the extant suboptimal administrative zones, without any recourse to population density (and by extension, spatial accessibility), see for example National Primary Health Care Development Agency (NPHCDA, 2012). The number of healthcare facilities provided in a region is therefore directly proportional to the number of administrative zones in a region irrespective of population density and accessibility. Not only does this result in poor accessibility for places with relatively larger (and as a result fewer) administrative zones, the overall effect is also staggering inequalities in the spatial accessibility of healthcare services to

[56] This illustrates one of the many benefits of the SMMR approach of this thesis, in that while qualitative methods alone would show that healthcare deserts in Kogi Central have much better accessibility to healthcare services than the deserts in the other two senatorial districts, it is unlikely that an exclusively qualitative researcher will realize (and be able to account for) the mediating influence of disparities in population density on their research findings. Population density is essentially a quantitative measure, it is unlikely to be measured/determined discursively or subjectively with qualitative methods.

the disadvantage of such places with larger and fewer administrative zones. Thus, a first step to resolving this and other associated concerns is the problematization of extant zoning systems and then the creation of optimized synthetic zoning systems for the current study. These optimized analytical zoning systems, among other things, also serve as both points of potential service provision and service demand for further analysis of accessibility as well as for Location–Allocation planning for the optimum spatial reorganization and/or expansion of healthcare services in the study area.

The next section empirically problematizes some of the extant administrative zoning systems in the study area with a view to developing synthetic alternatives that are optimized for the specific analytical (and mapping) purpose of this thesis. The ensuing empirical discussions reflect on the zone design criteria in Section 3.3.1.3, which serve as the proximal theoretical framework for this chapter.

4.3.1 Extant Wards versus Synthetic Replicas

The results of empirically problematizing the extant ward zoning systems (of the 3 demarcated LGAs) as well as comparing their characteristics with some optimized synthetic replicas are provided in Figure 4-7 and Table 4-6, Table 4-7, Table 4-8, and summarized in Table 4-9 below. Following this, optimized synthetic wards are created for the entire study area, targeting the total number of existing wards. Figure 4-8, Table 4-10 and Table 4-11 shows the characteristics of synthetic wards developed to emulate the number of extant wards in the entire study area. The advantages of optimized synthetic wards over the existing ward zoning system are summarized in Table 4-12. All the derived optimized ward zoning systems are further discussed in comparison with the existing number of zones, whose breakdown is shown in Table 4-4 and Table 4-5 above. Unless stated otherwise, the class breaks of all choropleth maps in this thesis are determined statistically by jenks natural breaks which minimize within-class variations while maximizing between-class variations (Jenks and Caspall, 1971; Jenks, 1977). This is a data mining approach for classifying choropleth maps which endogenously determines optimal class breaks, thereby producing more realistic spatial patterns than other methods (Smith, 1986; Brewer and Pickle, 2002; Cromley and McLafferty, 2012, p. 122).

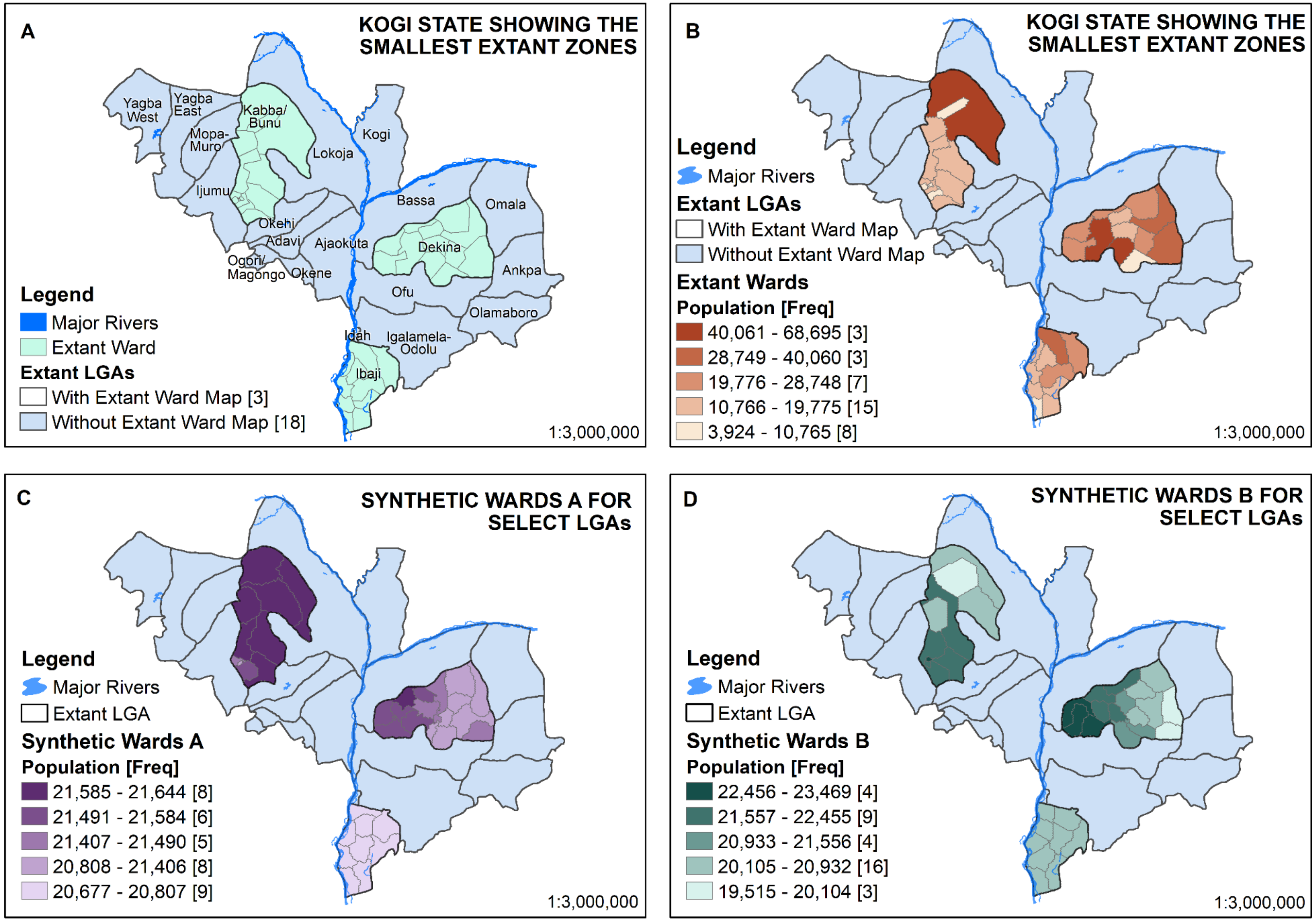


Figure 4-7 Extant versus synthetic wards, for 3 select LGAs in the study area (see Table 4-1 for the zone design criteria for Figures C and D)

Table 4-6 Soft Zoning *attributes of extant unoptimized Wards per Select LGAs, see Figure 4-7A and B for the associated maps.*

LGA	Ward Count	Population Min	Population Max	Population Mean	Population SD	Population Total	P2A[57] Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC[58] Score
Dekina	12	10612	68695	30410.417	15720.887	364925	23.27	53.717	34.023	9.549	408.28	-0.007
Ibaji	10	8323	38453	18663.2	8443.866	186632	22.774	38.49	31.874	4.409	318.737	-0.007
Kabba	14	3924	61758	15414	13784.915	215796	13.856	57.176	33.267	12.652	465.735	0.023
All 3	36	3924	68695	21315.361	14803.925	767353	13.856	57.176	33.132	9.937	1192.751	0.022

Table 4-7 Soft zoning attributes of optimized wards per select LGAs (for population balance), see Figure 4-7C and Table 4-1 for the relevant map and zone design criteria respectively.

LGA	Ward Count	Population Min	Population Max	Population Mean	Population SD	Population Total	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBA	6554	2	4902	117.082	247.514		13.856	13.856	13.856		90814.888	0.009
Dekina	17	21364	21603	21466.176	80.016	364925	24.634	49.487	35.739	8.775	607.57	-0.004
Ibaji	9	20677	20807	20736.889	44.732	186632	22.411	44.967	30.646	6.291	275.816	-0.007
Kabba	10	21349	21644	21579.6	87.494	215796	20.785	58.7	34.958	10.563	349.575	0.027
All 3	36	20677	21644	21315.361	345.606	767353	20.785	58.7	34.249	9.038	1232.962	0.009

Table 4-8 Soft zoning attributes of optimized wards per select LGAs (for shape compactness and population homogeneity), see Figure 4-7D and Table 4-1 for the relevant map and zone design criteria respectively.

LGA	Ward Count	Population Min	Population Max	Population Mean	Population SD	Population Total	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBA	6554	2	4902	117.082	247.514		13.856	13.856	13.856		90814.888	0.009
Dekina	17	19515	23203	21466.176	1076.326	364925	20.785	59.683	30.246	8.698	514.174	0.018
Ibaji	9	20542	20932	20736.889	114.082	186632	21.885	35.243	27.607	4.207	248.466	-0.007
Kabba	10	20104	23469	21579.6	1029.676	215796	19.245	73.101	34.86	18.273	348.604	0.023
All 3	36	19515	23469	21315.361	979.089	767353	19.245	73.101	30.868	11.84	1111.244	0.011

[57] Perimeter squared per area (P2A) is a measure of shape compactness, see Section 3.3.1.3

[58] Intra-Area Correlation (IAC) is a metric of intra-zonal homogeneity, see Section 3.3.1.3

Table 4-9 The difference between the number of extant wards and synthetic wards for the three select LGAs in the study area

LGAs	Number of Wards		Number of extant minus number of synthetic Wards
	Extant Wards	Synthetic Wards	
Dekina	12	17	-5
Ibaji	10	9	1
Kabba	14	10	4
All 3	36	36	-

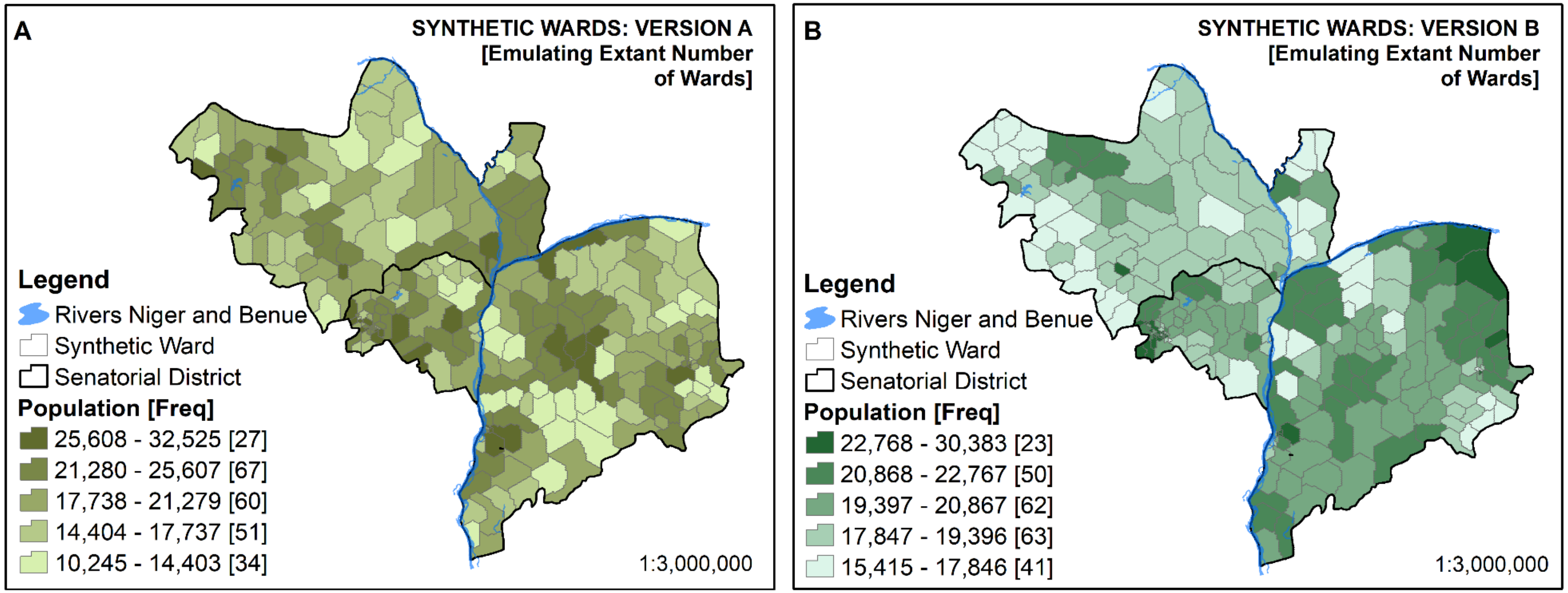


Figure 4-8 Two versions of synthetic optimized wards, emulating the number of extant wards in the study area, see Table 4-1 for the relevant zone design criteria.

Table 4-10 Soft zoning attributes of Figure 4-8A, whose zoning system emulates the number of existing wards in the study area (optimized for very compact of shapes), see Table 4-1 for the associated zone design criteria.

Senate District	Ward Count	Population Min	Population Max	Population Mean	Population SD	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBAs	29029	1	25602	164.318	600.629	13.856	13.856	13.856		402237.6	0.029
KG Central	63	10245	32112	21682.651	4696.242	13.856	40.418	23.271	6.196	1466.077	0.109
KG East	109	11468	32525	19327.716	4899.046	18.475	59.717	26.827	7.101	2924.106	0.044
KG West	67	12381	28347	19361.985	3964.808	18.585	40.53	27.8	5.53	1862.582	0.003
All LGAs	239	10245	32525	19958.079	4714.984	13.856	59.717	26.162	6.697	6252.765	0.026

Table 4-11 Soft zoning attributes of Figure 4-8B, whose zoning system emulates the number of existing wards in the study area, see Table 4-1 for the associated zone design criteria.

Senate District	Ward Count	Population Min	Population Max	Population Mean	Population SD	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBAs	29029	1	25602	164.318	600.629	13.856	13.856	13.856		402237.6	0.029
KG Central	65	16449	30383	21015.492	2484.629	13.856	47.364	24.802	7.512	1612.108	0.109
KG East	104	15415	24137	20256.933	1850.186	18.475	70.084	26.87	7.104	2794.516	0.055
KG West	70	15480	23064	18532.186	1578.529	19.159	58.965	27.61	6.663	1932.724	0.006
All LGAs	239	15415	30383	19958.079	2199.271	13.856	70.084	26.524	7.178	6339.349	0.029

Table 4-12 The difference between the number of extant wards and synthetic wards for the senatorial districts in the study area.

Senate District	Count			Difference	
	Extant Wards	Synthetic Wards A	Synthetic Wards B	Extant minus Synthetic Wards A	Extant minus Synthetic Wards B
Kogi Central	57	63	65	- 6	- 8
Kogi East	97	109	104	- 12	- 7
Kogi West	85	67	70	18	15
All LGAs	239	239	239	-	-

The results show that there are some inequities in the distribution of wards amongst LGAs and Senatorial districts. From the optimized synthetic wards for the select LGAs, Dekina LGA currently has a deficit of 5 wards while Ibaji and Kabba has a surplus of 1 ward and 4 wards respectively (see Table 4-9). This implies that the current ward zoning system greatly favours Kabba LGA to the disadvantage of Dekina LGA. In terms of population balance, optimized synthetic wards are more equitable than the extant wards of the 3 select LGAs. This is summarized by the Standard Deviations (SD) of population, of which the SD of population across all the extant wards is 14,804 while the optimized wards have SDs of 346 and 979 respectively (see Table 4-6). In this regard, the greatest inequity in population across select extant wards are exhibited in Dekina LGA with a SD of 15,721 while Ibaji LGA has the least inequity, with a SD of 8,444. In a similar vein, optimized synthetic wards (especially of Figure 4-7D with Table 4-8) are more compact and homogeneous than the existing wards in the three LGAs being considered.

The extant ward zoning system does not have mappable polygons for the entire study area; hence, it is only possible to compare the extant number of wards per senatorial district with their allocated number of synthetic wards based on the extant wards count of the study area. Since synthetic wards are optimized, they provide an equitable (or balanced) depiction of what the distribution of wards (per senatorial districts) should be if the current overall number of wards in the study area is equitably distributed across the senatorial districts. The summary of this comparison is presented in Table 4-12. This shows that Kogi West is the only unduly advantaged senatorial district in terms of the number of wards. It currently has 15 – 18 more wards than it should have if the current ward distribution is optimized for equity.

The foregoing analysis suggests the presence of remarkable inequities in the ward-level zoning system of the study area. In addition to the substantial inequality in the between-ward population (i.e. the imbalance shown from the population SD and range), as well as the other pitfalls of zone-based spatial analysis discussed in Section 3.3.1.2, the current wards have a mean population of 19,958, which is arguably too large for small-area analysis of certain geographical variables including primary healthcare services. Moreover, being available only as a gazetteer, there is no geographical demarcation (i.e. mappable geographies) for the extant wards in the study area. Consequently, without the use of automated zone design approaches, it is not possible to realistically conduct a ward-level analysis of any phenomena of geographical interest. Where available as maps, the use of extant wards in planning the location of healthcare facilities and other public sector facilities implies that LGAs and Senatorial Districts that are privileged in terms of their number of wards are likely to receive better healthcare coverage than other places, thereby perpetuating social-spatial inequities in the study area. The next section compares extant LGAs with their synthetic replicas. Not only does this further problematizes the extant zoning system, but it also aids our understanding of scale effects on zoning systems.

4.3.2 Extant versus Pseudo-LGAs

This section begins by showing relevant attributes of the extant LGA zoning system in the study area, grouped by senatorial districts. These are presented in Figure 4-7 and Table 4-13. Following this, six (6) versions of synthetic zoning systems that imitate the existing LGAs of the study area are presented and discussed. The first two versions are derived directly from the 1 km^2 hexagonal BBAs of this study. These are presented in Figure 4-9, Table 4-14 and Table 4-15. Thereafter, the remaining four (4) versions are derived from the synthetic ward zoning system discussed in Section 4.3.1 above (see Figure 4-9). These synthetic LGAs are shown in Figure 4-10, Table 4-16, Table 4-17, Table 4-18 and Table 4-19. The differences between extant LGAs and the six (6) versions of optimized LGAs are summarized in Table 4-20. The remainder of this section discusses these outputs briefly.

Table 4-13 The characteristics of the extant LGA zoning system of Kogi State, see Figure 4-7A for the LGA map

Senate District	LGA Count	Population Min	Population Max	Population Mean	Population SD	Total Pop.	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
Kogi Central	5	54188	485583	273220	145495.606	1366100	26.785	66.268	47.107	15.518	235.537	-0.004
Kogi East	9	103940	379029	234077	85981.214	2106693	29.228	67.104	39.671	11.053	357.037	0.014
Kogi West	7	63170	286705	185367	62812.824	1297569	31.142	76.667	49.084	14.28	343.585	-0.004
All LGAs	21	54188	485583	227160.095	103109.452	4770362	26.785	76.667	44.579	14.01	936.158	0.007

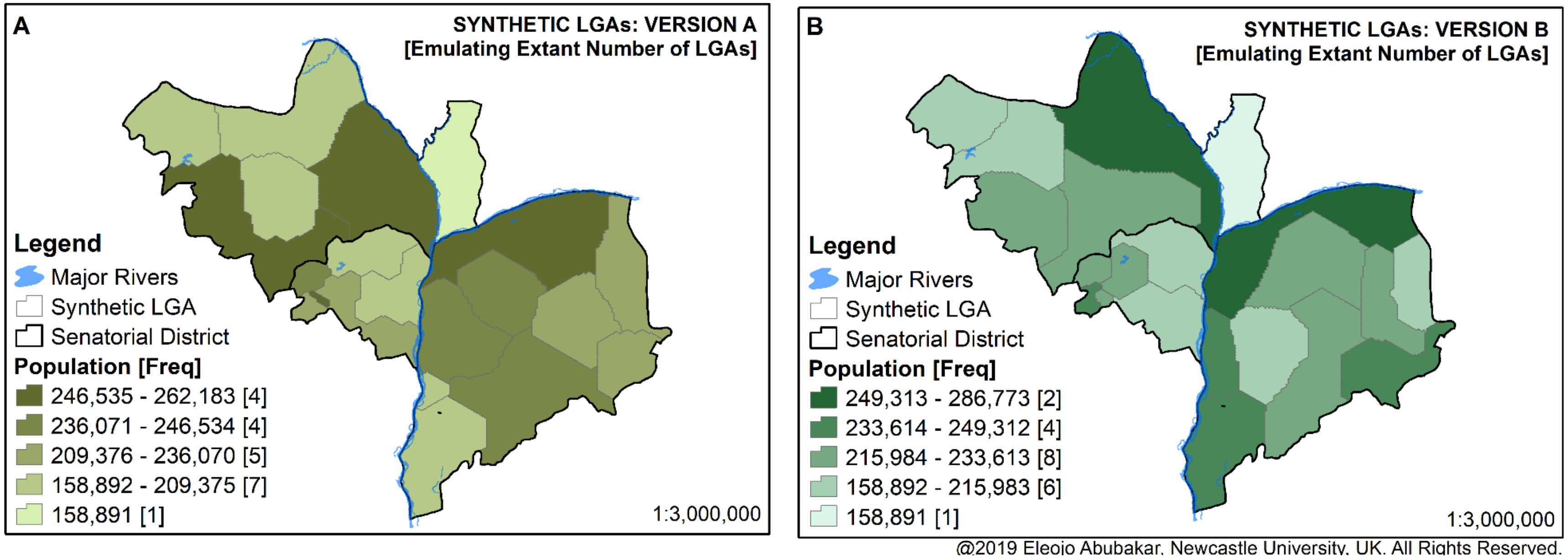


Figure 4-9 Two versions of synthetic Local Government Areas (LGAs) emulating the extant number of LGAs, derived from 1km² hexagonal building block areas. See Table 4-2 for the zone design criteria, and Table 4-14 and Table 4-15 for the associated statistics.

Table 4-14 Synthetic LGAs (Figure 4-9A) created from 1 km² hexagonal building blocks (for the zone design criteria, see Table 4-2).

Senate District	LGA Count	Population Min	Population Max	Population Mean	Population SD	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBAs	29029	1	25602	164.318	600.629	13.856	13.856	13.856		402237.6	0.029
Kogi Central	6	209791	249312	227667.833	13814.198	20.811	40.815	30.083	7.967	180.496	0.007
Kogi East	9	204546	281620	234080.111	20148.982	22.928	59.498	36.094	11.226	324.842	-0.008
Kogi West	6	158891	286773	216208.833	39874.845	27.192	47.35	37.973	7.645	227.839	-0.002
All LGAs	21	158891	286773	227141.952	27159.972	20.811	59.498	34.913	9.939	733.177	0.009

Table 4-15 Synthetic LGAs (Figure 4-9B) created from 1 km² hexagonal Building Block Areas (BBAs) (for the zone design criteria, see Table 4-2).

Senate District	LGA Count	Population Min	Population Max	Population Mean	Population SD	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBAs	29029	1	25602	164.318	600.629	13.856	13.856	13.856		402237.6	0.029
Kogi Central	6	199852	262183	227667.833	21826.158	25.225	61.586	35.368	12.03	212.207	0.031
Kogi East	9	201263	260012	234080.111	17754.669	21.427	43.404	31.548	8.386	283.93	-0.004
Kogi West	6	158891	257517	216208.833	33925.859	21.315	77.389	39.533	18.3	237.196	-0.001
All LGAs	21	158891	262183	227141.952	25591.317	21.315	77.389	34.921	13.348	733.333	0.012

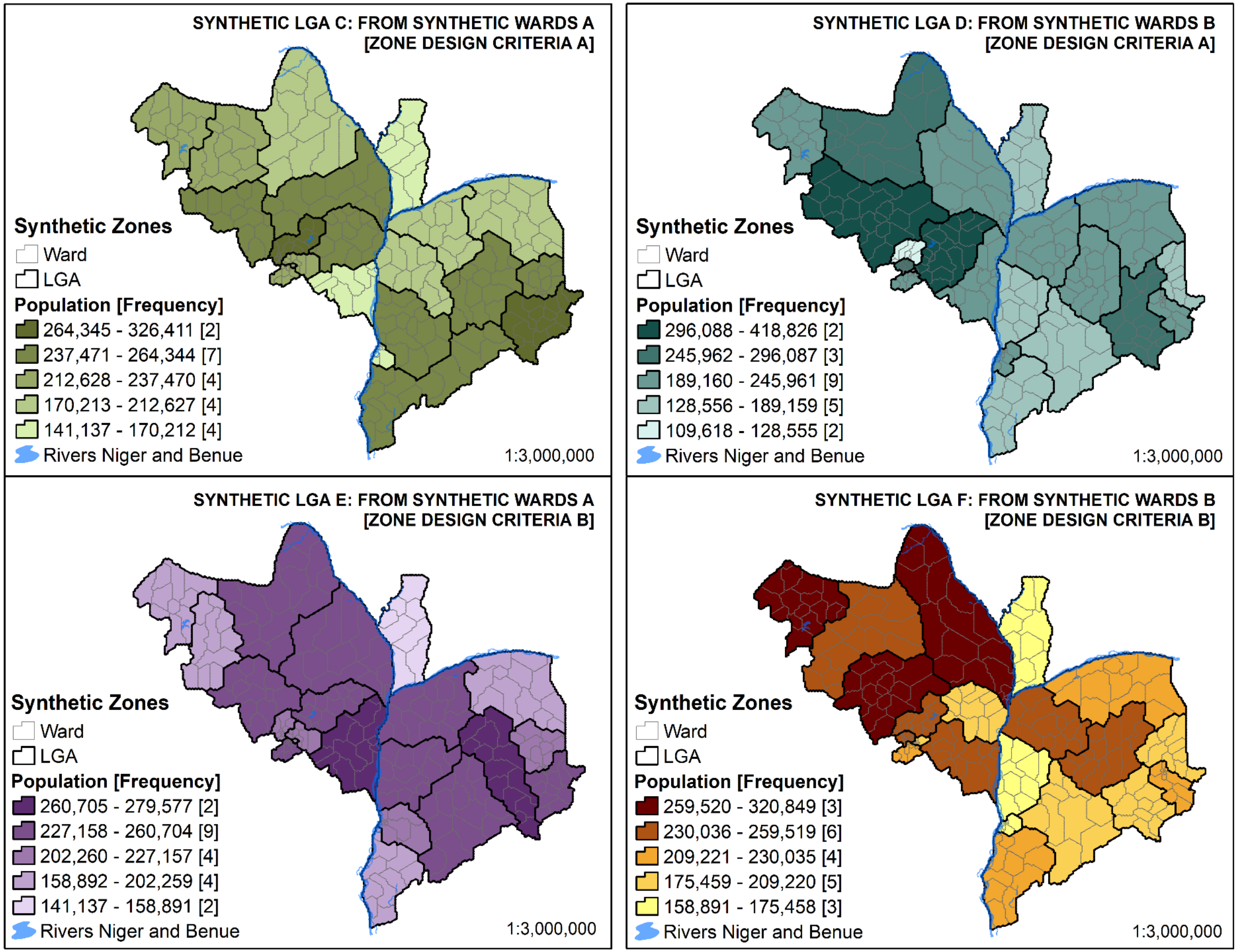


Figure 4-10 Four versions of synthetic LGAs derived from synthetic wards of the study area, using various automated zone design criteria presented in Table 4-2, with their associated zoning attributes in Table 4-16, Table 4-17, Table 4-18, and Table 4-19.

Table 4-16 Soft zoning attributes of synthetic LGAs C (see Figure 4-10C, Top LHS) created from synthetic Wards A (see Figure 4-8A) as BBAs, using relevant zone design criteria in Table 4-2.

Senate District	LGA Count	Population Min	Population Max	Population Mean	Population SD	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBAs	239	10245	32525	19958.079	4714.984	13.856	59.717	26.162	6.697	6252.765	0.103
Kogi Central	6	141137	326411	227667.833	59912.559	19.245	38.776	30.539	6.431	183.234	0.115
Kogi East	9	164939	289653	234080.111	38015.25	23.807	65.797	35.618	11.902	320.559	0.019
Kogi West	6	158891	250189	216208.833	31835.702	32.346	50.766	39.825	6.105	238.95	-0.002
All LGAs	21	141137	326411	227141.952	44602.313	23.286	65.797	35.561	9.491	746.784	0.086

Table 4-17 Soft zoning attributes of synthetic LGAs D (see Figure 4-10D, Top RHS) created from synthetic Wards B (see Figure 4-8B) as BBAs, using relevant zone design criteria in Table 4-2.

Senate District	LGA Count	Population Min	Population Max	Population Mean	Population SD	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBAs	239	15415	30383	19958.079	2199.271	13.856	70.084	26.524	7.178	6339.349	0.106
Kogi Central	6	109618	418826	227667.833	104003.038	19.707	46.636	30.451	8.309	182.707	0.134
Kogi East	10	153162	274961	210672.1	34017.448	25.918	48.775	34.429	7.064	344.292	0.021
Kogi West	5	158891	380636	259450.6	75151.008	32.053	42.08	37.764	3.918	188.818	-0.005
All LGAs	21	109618	418826	227141.952	73239.169	19.707	48.775	34.086	7.362	715.816	0.091

Table 4-18 Soft zoning attributes of synthetic LGAs E (see Figure 4-10E, Bottom LHS) created from synthetic Wards A (see Figure 4-8A) as BBAs, using relevant zone design criteria in Table 4-2.

Senate District	LGA Count	Population Min	Population Max	Population Mean	Population SD	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBAs	239	10245	32525	19958.079	4714.984	13.856	59.717	26.162	6.697	6252.765	0.103
Kogi Central	6	141137	276930	227667.833	43774.61	19.245	36.921	29.981	5.838	179.889	0.112
Kogi East	9	198304	279577	234080.111	23956.993	26.075	42.727	34.356	5.048	309.208	0.007
Kogi West	6	158891	260704	216208.833	33854.242	33.308	43.581	38.3	3.898	229.798	-0.004
All LGAs	21	141137	279577	227141.952	34289.729	23.286	43.581	34.426	5.465	722.936	0.085

Table 4-19 Soft zoning attributes of synthetic LGAs F (See Figure 4-10F, Bottom RHS) created from synthetic Wards B (see Figure 4-8B) as BBAs, using relevant zone design criteria in Table 4-2.

Senate District	LGA Count	Population Min	Population Max	Population Mean	Population SD	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBAs	239	15415	30383	19958.079	2199.271	13.856	70.084	26.524	7.178	6339.349	0.106
Kogi Central	6	196404	251926	227667.833	22028.564	26.24	39.675	31.462	4.864	188.771	0.08
Kogi East	10	172675	240922	210672.1	24259.805	24.312	42.329	34.475	5.143	344.755	0.027
Kogi West	5	158891	320849	259450.6	54124.645	36.001	43.495	39.062	3.074	195.312	-0.006
All LGAs	21	158891	320849	227141.952	38654.622	24.312	43.495	34.797	5.271	730.746	0.08

Table 4-20 The difference between the number of extant LGAs and synthetic LGAs for the senatorial districts in the study area.

LGA Count							
Senatorial District	Extant LGAs	Synthetic LGA (Version A)	Synthetic LGA (Version B)	Synthetic LGA (Version C)	Synthetic LGA (Version D)	Synthetic LGA (Version E)	Synthetic LGA (Version F)
Kogi Central	5	6	6	6	6	6	6
Kogi East	9	9	9	9	10	9	10
Kogi West	7	6	6	6	5	6	5

LGA Difference (Extant Zone Count minus:)						
Senatorial District	Version A	Version B	Version C	Version D	Version E	Version F
Kogi Central	-1	-1	-1	-1	-1	-1
Kogi East	0	0	0	1	0	1
Kogi West	1	1	1	2	1	2

The zoning system of extant LGAs embodies noteworthy inequities, although to a lesser extent than the zoning system of existing wards. The difference between the extant number of LGAs and the number of optimized synthetic LGAs is summarized in Table 4-20. Regardless of differences in the zone design criteria and the type of BBA utilized (i.e. 1 km^2 hexagon or synthetic wards), there is some degree of consistency in the number of LGAs in the three senatorial districts, across the six (6) versions of optimized synthetic LGAs created. Overall, Kogi Central is slightly disadvantaged in this regard, while Kogi West has more LGAs than it is allocated by the optimized synthetic LGAs.

All the optimized synthetic LGAs have more equitable population distribution across senatorial districts than the extant LGAs. While the SD of population for the extant LGAs is 103,109, the SD of populations for the various versions of synthetic LGAs range from 25,591 to 73,239. Therefore, there are some variations in the degree of population balance achieved by the various synthetic LGAs, depending on both the BBAs and the zone design criteria used. Synthetic LGAs derived from the 1 km^2 hexagonal BBAs provide better population balance across LGAs (SD of 25,591 and 27,160) than what is achieved by the synthetic LGAs derived from the synthetic wards (SDs of between 34,289 to 73,239). This supports Cockings *et al.* (2013) findings that fine scale BBAs are likely to produce more balanced (i.e. equitable) synthetic zoning systems than coarse BBAs. Small-sized BBAs allow better combinatorial flexibility in meeting required zone design criteria with regards to population balance.

The mean compactness of synthetic LGA shapes remain similar across all the six (6) versions, regardless of the zone design criteria and BBA used (with P2A of between 34.5 and 35.6). With lower P2A metric comes more compact shapes of zones in an area. Since extant LGAs have a mean P2A score of 44.6, synthetic LGAs are generally more compact than the extant LGAs of the study area. Furthermore, the synthetic LGAs in Kogi West have the least compact shapes across all versions of synthetic LGAs, while Kogi Central has synthetic LGAs with the most compact shapes across most versions of synthetic LGAs simulated. This can be alluded to variations in the population density across the various senatorial districts (see Table 4-4), such that with increased population density comes smaller and more compact-shaped synthetic zones. Furthermore, of all the three (3) senatorial districts, only Kogi West is bisected by one of the major rivers in the study area. The need to respect geometric constraints like physical barriers or other existing administrative zones usually reduces the optimization outcomes of zone design algorithms.

With increasing value of IAC comes better homogeneity across zones (compare Table 4-13 with Table 4-14 to Table 4-19). For the entire study area, it appears that to varying extents, all the synthetic LGAs are more homogeneous than the extant LGAs. However, for each senatorial district, it is not certain that all the synthetic LGAs perform better than the extant LGAs in terms of internal homogeneity. This could be because it is axiomatically more difficult for large-sized zones like the synthetic LGAs to be as homogeneous as smaller-sized synthetic zones, like the wards.

4.3.3 Optimized Small-Area Zones for Primary Healthcare Analyses

Having problematized the existing zoning systems of the study area at two spatial scales (i.e. wards and LGAs), two optimized small-area zoning systems are created for the analyses of small-area variations in primary healthcare accessibility in this study. The first zoning system targets an optimum population of 15,000 persons. Nested within this, is a second optimized zoning system that targets an optimum population of 5,000. These zonings systems as well as their respective soft attributes are shown in Figure 4-11 and Table 4-21, respectively. Being permeable subnational boundaries, spatial accessibility is not constrained by the boundaries of extant administrative zones; hence, the developed analytical zoning systems disregard the existing administrative boundaries in the study area. However, because large rivers greatly influence road transportations in the study area, by serving as barriers in places without bridges, the analytical small-area zoning systems respect the constraints of the major rivers. The effect is that no small-area zone is bisected by a major river. Not only is this intuitive and corresponds with the design of current administrative zoning system in the study area, this greatly enhances the empirical realism of this study in that stark differences in accessibility indices (and other related measures) can be observed in adjacent small-area zones separated by a major river. This is observable in the results of Chapters 6 by comparing adjacent sides of a major river (especially in sections without a bridge).

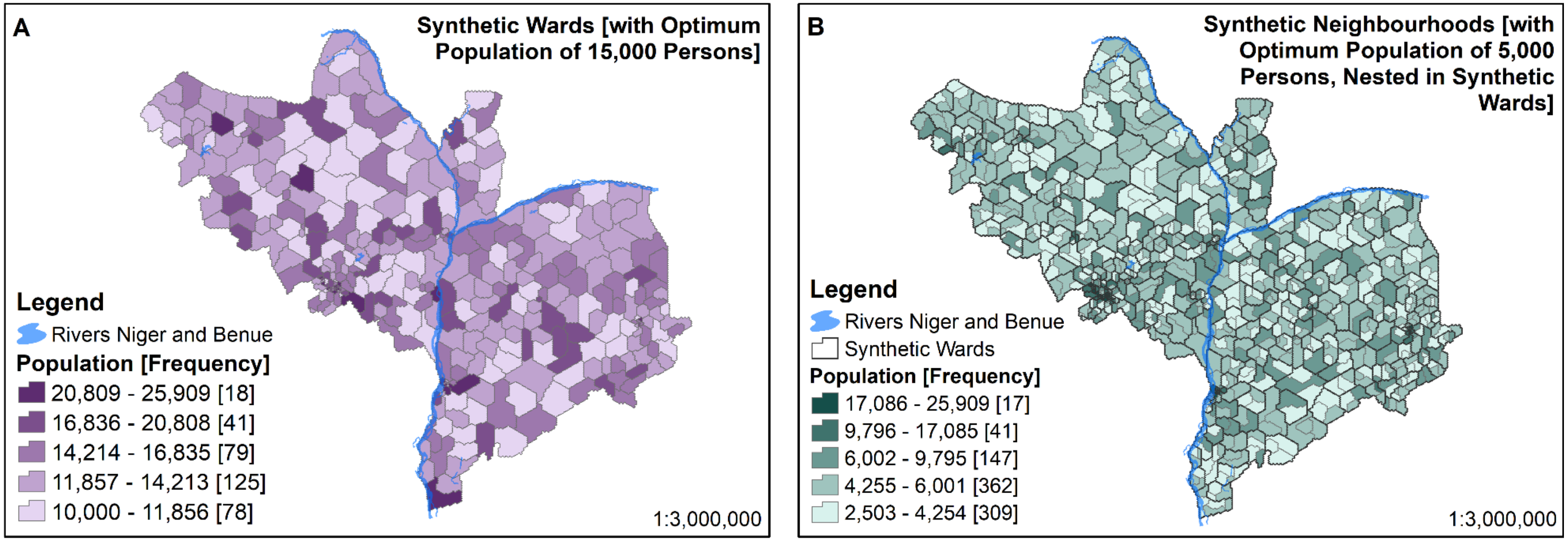


Figure 4-11 Maps of the optimized small-area analytical zoning systems of the study area.

Table 4-21 Soft characteristics of the optimized small-area analytical zoning systems for the socio-spatial analysis of accessibility of primary healthcare services.

Type of Synthetic Zoning System	Count	Population Min	Population Max	Population Mean	Population SD	P2A Min	P2A Max	P2A Mean	P2A SD	P2A Score	IAC Score
BBAs	29029	1	25602	164.32	600.63	13.86	13.86	13.86		402237.6	0.03
Ward	341	10000	25909	14257.79	3292.42	13.86	58.52	24.60	5.90	8388.33	0.03
Neighbourhood	876	2503	25909	5550.12	3277.89	13.86	55.43	25.04	5.90	21936.89	0.03

Further details of the zone design criteria for the small-area analytical zoning system used for further spatial analytics in this thesis are presented in Table 4-3. The remainder of this section discusses the optimized small-area analytical zoning system based on the well-established zone design criteria discussed in Section 3.3.1.3. Comparisons are also made with the extant (and emulated) ward zones characterized in Section 4.3.1 in the context of the requirements of this research project.

Aside from the problematic situation whereby extant ward zones are not demarcated for the entire study area, the ward demarcations available for only 3 LGAs (of the 21 LGAs in the study area) fall short in general zoning criteria as well as in the specific analytic requirements of this research project, as discussed in Section 3.3.1.3. The minimum population of extant wards is 3,924, while that of synthetic wards is 10,000. This shows that some extant wards do not meet Nigeria’s population threshold requirements (i.e. 10,000 persons) to sustain a potential primary healthcare centre (NPHCDA, 2018b, 2018c). The mean population of all 36 demarcated extant wards is 21,315; while the optimized synthetic analytical wards of this study have a mean population of 14,258. This implies that optimized wards have finer and better analytical scale than extant wards (as well as their synthetic replica). Invariably, this is related to the number of zones, because with a smaller mean population of a zoning system comes an increased number of zones. With a greater number of zones comes the ability to show more spatial details and spatial variations in mapping and analysis. Thus, whereas the total number of extant wards for the entire study area is 239, there are 341 optimized synthetic analytic wards for this study.

In terms of standardized population size and balance, the population range as well as the population Standard Deviation (SD) of zones are both much smaller for the synthetic analytical wards. While extant demarcated wards have population range and SD of 64,771 and 14,804 respectively, synthetic analytical wards have 15,909 and 3,292 respectively. As discussed in Section 3.3.1.3, large population range and SD of zoning systems signify a low balance and non-standardization in terms of population size. The synthetic analytical zoning systems are therefore much more equitable and egalitarian than the extant demarcations of wards in the study area, making them well-suited for the current study, which is attentive to the distributive justice of healthcare accessibility.

Synthetic analytic wards also outperform the extant ward demarcations in terms of shape compactness. The average P2A score as well as the P2A standard deviation for synthetic wards are 24.6 and 5.9 respectively, both of which are lower than the scores for the extant wards, being 33.13 and 9.94 respectively. Therefore, not only are synthetic wards more compact than extant wards, there is less variation in the degree of shape compactness of synthetic wards, relative to the extant ones. As discussed in Section 3.3.1.3, more compact zones enhance the overall spatial accessibility of a zoning system, and are also more aesthetically appealing (Angel *et al.*, 2010; Li *et al.*, 2013, p. 1228). This means that optimized analytical zoning systems are better suited for visual assessment and interpretation of the spatial patterns in mapped variables. Furthermore, with more compact zones come better placed zonal centroids, which serve as aggregate demand points as well as potential supply points for an optimal spatial re-organization and/or expansion of primary healthcare services in the study area. This minimizes aggregation errors in the zonal demand centroids used for analyzing spatial accessibility in Chapter 6, as well as in subsequent Location-Allocation modelling, which is the overall goal of this study, going forward.

4.3.4 Further Implications of Zoning Systems in Nigeria

Sections 4.3.1 and 4.3.2 demonstrate among other things that there is dire inequity in the present zoning system of the study area, one which varies by LGA and senatorial districts. Being that the study area is a microcosm of the country, Nigeria, it therefore implies that the observed zoning inequities are symptomatic of broader national zoning inequities across the dominant geopolitical divides/regions of the country. The implications of this are dire and multidimensional, requiring further elaborations which are beyond the scope of the current study.

The distribution of political power/representation, the collection of public sector data, as well as public sector policies, plans, programmes and strategies in Nigeria are based on these arbitrary districts/zones (either administrative, political, statistical, etc) that have now been shown to be inequitable and suboptimal. This is therefore a dire and foundational structural inequity that drives/perpetuates and intensifies socio-spatial inequity in many other spheres of the Nigerian society, including socio-economic and health status. Without adequately controlling for the effects of these structural inequities in the existing zoning system, survey programs (like the MICS and DHS), plans, policies, and public interventions (and so on) that are implicitly or explicitly based on these extant suboptimal administrative/political zoning system will therefore produce inferences/findings that are biased and misrepresentational as a function of the extent of inequity in the extant zoning system utilized (Ajebon, 2019, p. 119; Ballas *et al.*, 2019, p. 72). Weighting adjustments (like post-stratification weighting) used to correct for representational errors in the statistical analysis of sample surveys mainly account for social (and demographic) biases in complex multi-stage sampling designs of surveys (Pfeffermann, 1996; Aday and Cornelius, 2006, p. 185; Lee *et al.*, 2006, p. 11; Campbell and Berbaum, 2010; Brady *et al.*, 2018). Many of these weighting adjustments are in themselves products of spatial zoning systems, which are inherently suboptimal in many contexts, as this chapter has abundantly shown. Although useful with natural or concrete groupings (like households, sex, religion, watersheds etc), weighting adjustments that are a function of artificial suboptimal zoning systems (like administrative or census enumeration zones), are likely to perpetuate and/or intensify the socio-spatial inequities which are inherent in the arbitrary zoning systems upon which they are based. Therefore, the use of weighting adjustments that remedy only one aspect of representational bias (i.e. the social aspect) are of little remedial effect because of the cyclic and self-reinforcing relationship between social and spatial dimensions of human society (Soja, 1980). This is also a matter for further exploration beyond the scope of this thesis.

An exemplar of the effects of arbitrary/suboptimal zoning systems in Nigeria is the provision of essential healthcare services and personnel that are planned according to extant political districts in the country. The framework for primary healthcare provision in Nigeria, as set out in the Ward Minimum Healthcare Package (WMHCP) of the National Primary Healthcare Development Agency (NPHCDA) of Nigeria, is based exclusively on the extant administrative zoning system which has now been shown to be very suboptimal (NPHCDA, 2012). For instance, according to this framework, each ward is eligible to have one primary healthcare facility (with a standard modicum of associated healthcare personal and services) regardless of their population size or density. This implies that even wards that do not meet the specified minimum population thresholds for sustainable provision of PHC facilities in Nigeria (i.e. 10,000 persons) are provided with one PHC (see Figure 4-7B), an inefficient/wasteful specification as well as a profound issue of inequity. Furthermore, regions that may have been suppressed or disadvantaged by the allocation of relatively fewer political zones (i.e. wards or LGAs) would suffer further consequences including poorer spatial accessibility to primary healthcare services and vice versa. The allocation of national resources and other public infrastructure tends to follow a similar pattern, thereby entrenching and intensifying socio-spatial inequities in various other developmental dimensions.

Indeed, the extant 'arbitrary' administrative zoning systems in Nigeria are the result from historical processes of inequities in political power. The effect is that population sub-groups and/or regions that were disadvantaged/deprived or suppressed (in terms of political power) at the time of creating and/or modifying these regions suffered a dire disadvantage in the resulting zoning system. These historical processes of power inequality are manifest in contemporary times and are reinforced (in part) by the extant inequity in the administrative zoning, operating in concert with other facets of inequities in Nigeria. Consequently, in addition to the current clamour for (constitutional) restructuring in the country, there is a need for routine redistricting of the political/administrative zoning system in the country - a form of geo-political restructuring. In addition to optimizing the current lopsided zoning system, periodic redistricting is necessitated by changing demographics and is the standard practice in many HICs (Kalcsics, 2015, p. 597). For example, political districts are revised every five (5) years in New Zealand and every decade in the US and Canada (after each census).

In the final analysis, even though the restructuring of current administrative boundaries in Nigeria is a Political Districting Problem (PDP), which requires additional zone design criteria to the ones considered in this chapter, it is necessary for relevant authorities to be aware and mindful of these concerns. In these contexts, analytical zoning systems need to be created for various applications, as this study has done. This helps to ensure that relevant measures are put in place to account or control for these zoning inequities as much as possible. Statistical data collectors (i.e. agencies that conduct surveys), especially those that use probability sampling techniques as well as spatial analysts, are therefore urged to pay greater attention to the nature of extant administrative geographies in the country. With some places having a much higher number of administrative zones than others, there is a tendency for sample surveys based on the current zoning system to over-represent the demographic and socioeconomic attributes of such places, while the attributes of other places with fewer assigned administrative zones are under-represented and/or suppressed (Ballas *et al.*, 2019, p. 72). It is not likely that the respondent/case weighting routines employed for statistical analysis purposes are able to adequately account for this type of representational bias.

4.4 Summary and Conclusion

This chapter begins by problematizing the existing zoning system of the study area. Through various automated zone design experiments, many versions of optimum synthetic zoning architecture are created as alternatives to and improvements of the extant zoning system. Lastly, two optimum small-area zoning systems appropriate for small-area spatial analysis and mapping of healthcare accessibility and inequity in the study area are developed with optimum populations of 15,000 and 5,000 persons respectively. The inherent problems with extant zoning systems are illustrated with zoning experiments that compare extant zones with their synthetic surrogates. The advantages of using spatial optimization algorithms for robust development of optimized zoning systems are demonstrated with real data of the study area. These experiments also show that the architecture of the BBAs utilized affects the resulting optimized small-area zones, especially for zoning systems with large tracts (Cockings *et al.*, 2013). Thus, it is advisable that when there is a need to create optimal large-area zoning systems (like LGAs with optimum populations of 20,000 or more), it is necessary to create an intermediate optimized small-area zoning system (like synthetic neighbourhoods with optimum populations of 5,000 persons or less), from which requisite large-area optimized zoning systems are then created. This also helps the performance of the optimization model; in that, it is likely to create optimal solutions from a smaller number of optimized BBAs (requiring fewer algorithmic searches) than from a large number of BBAs (which would involve large heuristic searches). Furthermore, when optimized large-area zoning systems are created from optimized intermediate zones as building blocks, the resulting large-area optimized zoning system tends to be more realistic (or plausible) than those created without the use of intermediate zones.

In addition to reducing or eradicating some of the inherent shortcomings of using aggregated population data for spatial analytics (such as MAUP, ecological fallacy, small population problem and UGCoP), optimized small-area geographies are also appropriate need/demand aggregation zones for planning the optimal spatial re-organization and/or expansion of the healthcare services' constellation in the study area. The optimized synthetic small-area zoning systems serve to minimize aggregation-induced errors in programmatically prescribed optimal coverage scenarios of healthcare services. As would be shown in further aspects of this research project (outside the scope of this doctoral thesis), Location-Allocation modelling for equitable healthcare planning (which typically require the calculation of distances between the centroids of need/demand zones and health services' supply points) would be more optimal if they are based on optimized zoning systems, such as those developed in his chapter. Hence, in addition to helping to reduce the complexity of routing and location problems, the optimized aggregation of need/demand has other important implications for accessibility and location modelling (Sadigh and Fallah, 2009; Cromley and McLafferty, 2012, p. 362). For instance, in location modelling, aggregation zones result in the under- or over-estimation of the actual travel time or distance for individuals (Kwan, 1998, 1999), thereby serving as a source of error, which implies that a modelled optimal healthcare coverage pattern may be suboptimal at the individual- or small-area level (Bach, 1981; Daskin *et al.*, 1989; Current and Schilling, 1990; Francis *et al.*, 2009). Furthermore, variations in the configuration of spatial units can greatly undermine the optimality of modelled facility location to the extent of making such outputs unreliable for planning purposes (Goodchild, 1979; Fotheringham *et al.*, 1995). As shown in Section 4.3, this also helps to determine the optimal number and location of aggregate demand and supply centroids of potential healthcare services in a study area. In this way, the findings of this study are more consistent and reliable than ordinarily would have been possible if it was based on extant unoptimized/arbitrary (small-area) zoning systems. Small-area estimation of relatively precise multivariate indicators of needs for PHC services is the subject of the next chapter.

Chapter 5. Small-Area Estimation of Standard SDG Indicators of Primary Healthcare Needs: Spatial Microsimulation Modelling

5.1 Background

In order to adequately consider spatial dimensions of relevant theorizations in the social sciences, it is essential to use spatially centred methodologies (like Spatial Microsimulation Modelling (SMM)) to link large, publicly available, Sample Survey Data (SSD) to space in both micro and aggregate forms (Goodchild and Janelle, 2004; Howell and Porter, 2010, p. 683). This type of linkage provides researchers with spatially enriched socioeconomic databases with which to answer complex research questions that are otherwise intractable with either survey or aggregated zone data alone (Chhetri and Stimson, 2014, p. 532). Simple methods for linking survey data with zonal data are well-known (Howell and Porter, 2010; Chhetri and Stimson, 2014). However, not only are they univariate, but they are also not sufficiently robust. Therefore, they are unable to adequately account for the complex socio-spatial nature of many phenomena of research interest in the social sciences, including healthcare accessibility. In Section 3.3.2, it is explained that SMM is arguably the most robust method for linking SSD with aggregate zoning data, a procedure known as population synthesis. It is also the main geographical approach for small-area estimation. However, instead of utilizing (conventional) readily available census aggregate data, the spatial constraints used for SMM in this chapter is derived from gridded demographic data aggregated for the synthetic analytical zones. This therefore makes it possible to simulate a spatially-enriched synthetic population for the bespoke optimized zoning system of this thesis.

Further to Section 3.3.2, SMM belongs to the broad group of methods for population synthesis (Kirill and Axhausen, 2011; Harland *et al.*, 2012a; Vovsha *et al.*, 2015). In the current chapter, population synthesis, which fuses SSD with optimized synthetic zones is also helpful in further minimizing the nontrivial ecological fallacy problem of readily available zoning systems (Howell and Porter, 2010, p. 692; Johnston and Sidaway, 2016a, p. 152). A spatially enriched individual-level population of the study area is synthesized using SMM. Gridded demographic data (from WorldPop's grid) is combined with UNICEF's Multiple Indicator Cluster Survey (MICS 5 of 2016 – 2017) microdata to create a spatially enriched synthetic micro-population of the study area, as illustrated in Figure 5-1. The derived synthetic micro-population is then used to compute some standard SDG-related indicators for the analytical small-area zones of the study area, with further data disaggregation according to key socioeconomic dimensions, PROGRESS. This helps to overcome a major downside of national sample surveys, which typically can only be used for data disaggregation at regional or provincial levels instead of the district or small-area levels (O'Connell *et al.*, 2015, p. 11).

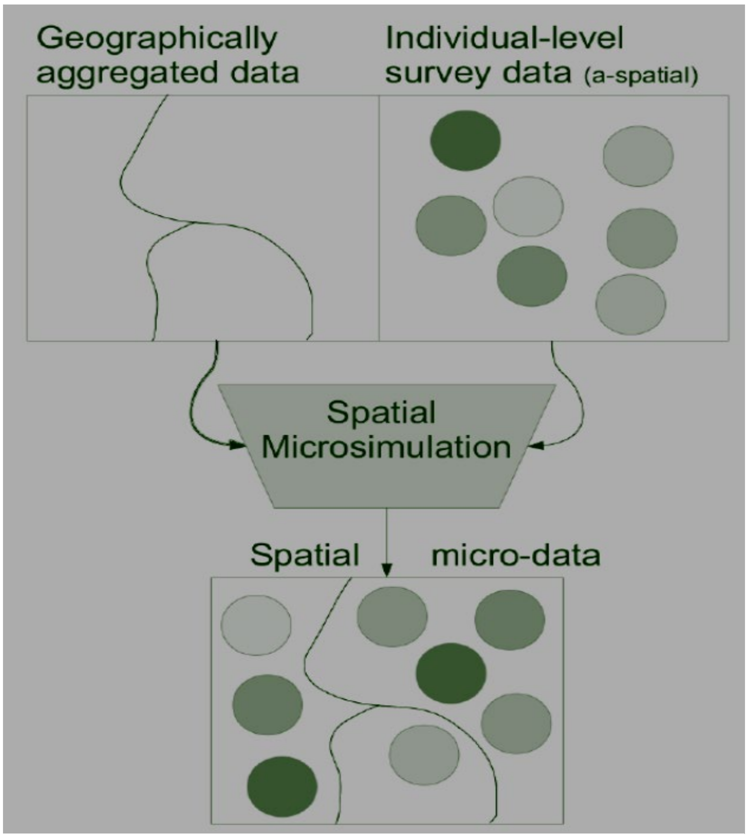


Figure 5-1 Schematic diagram contrasting conventional official data (above) against spatial microdata produced during population synthesis (Lovelace and Dumont, 2016, p. 8)

Having reiterated some key benefits of SMM for linking rich socioeconomic data with aggregate zonal data and then small-area estimation, there are two (2) main objectives of this chapter. The first is to simulate a spatially-enriched synthetic population by linking sample survey microdata with optimized analytical small-area zones (developed in Chapter 4). This is achieved with SMM, making it possible to further link and co-analyze various other types of contextual information at multiple spatial scales, with the rich socioeconomic data of sample surveys. The second main objective is to utilize the enriched synthetic individual-level population (from the foregoing objective) to estimate standard (i.e. SDG-related) multivariate indicators of healthcare need or utilization for the optimized synthetic ward zoning system. In particular, standard small-area multivariate MDG or SDG indicators of HIV/AIDS and sexual behaviour are estimated with a view to facilitating precise geographical targeting of HIV-related interventions (Slaymaker, 2004; UNAIDS and United Nations General Assembly Special Session on HIV/AIDS, 2007; Mmari and Sabherwal, 2013; Anderson *et al.*, 2017). Similar indicators and data have been used by other studies, except that these are not disaggregated at small-area scales like the current study (Ghys and Garnett, 2010; Doyle *et al.*, 2012; Hajizadeh *et al.*, 2014; Akinyemi, 2016; Lucas and Wilson, 2019). The estimated small-area number of sexually active persons also serves as the need variable for analyzing the spatial accessibility of family planning services in Chapter 6 (Anderson *et al.*, 2017).

Not only is HIV/AIDS endemic in the study area, but it is also relatively more difficult to estimate HIV/AIDS-related healthcare needs for small-areas for a variety of reasons, including confidentiality and the resulting paucity of relevant data (Cuadros *et al.*, 2017). Furthermore, the estimation of HIV/AIDS-related sexual behaviour indicators from national household surveys involves the simultaneous use of multiple survey variables as opposed to a single variable. Thus, HIV/AIDS indicators are multivariate, being derived from multiple variables in a relatively complex manner. It is therefore not surprising that there is a scarcity of HIV/AIDS-related data, even at coarse spatial scales, such that reputable data modellers like the WorldPop are yet to produce reliable HIV/AIDS-related grids as they have been able to do with various other morbidity types. The foregoing objectives also make it possible to use the spatially enriched synthetic population to disaggregate the computed spatial accessibility indices (in Chapter 6) according to relevant socioeconomic markers. In this way, not only are variations in spatial accessibility portrayed for the optimized small-area analytical zones of the study area, they can also be disaggregated according to relevant socio-economic markers like income quintile, religion, ethnicity (and so on) in subsequent works. An overview of standard indicators of sexual behaviour and HIV/AIDS is provided in the next section as a prelude to explaining the specific data analysis steps of this chapter.

5.2 Overview of Standard Indicators of HIV/AIDS and Sexual Behaviour

MICS 5 provides data on more than 300 internationally agreed-upon indicators covering all the themes of the SDGs (NBS and UNICEF, 2017). However, these indicators are only available at very large sub-national aggregation and cannot be computed for small-areas (like wards, districts, or neighbourhoods) of the study area; hence, the need to use SMM for small-area estimation. In this chapter, select health-related MICS 5 indicators under the theme 'HIV/AIDS and Sexual Behaviour' are estimated for the small-area optimized analytical ward zoning system developed in Chapter 4. Some of these small-area estimates serve as surrogates of realized healthcare access (i.e. utilization) (especially MICS 5 Indicators 9.5 and 9.6) and need for HIV/AIDS-related services (especially MICS 5 Indicators 9.12, 9.13, 9.14 and 9.15) in the study area (Anderson *et al.*, 2017). Others include MICS 5 Indicators 9.1 (or MDG Indicator 6.3) and 9.4.

The computation of these indicator estimates follows the standard MICS 5 indicator computation algorithms but is adapted to account for the new small-area geographies ascribed to the synthetic individual-level population. Other relevant disaggregation variables, not considered in the original algorithms are also included, particularly the Ethnicity and Religion of Household Heads. The standard MICS 5 Indicator computation algorithms are provided as SPSS syntax files (.sps) on the MICS 5 website: http://mics.unicef.org/tools?round=mics5#data-processing. These syntax files were modified accordingly in the following ways:

- In the original syntax files, separate MICS 5 indicators (with their corresponding tables) were calculated for males and females. In this project, male and female SSD are merged so that unified indicators are calculated for both sexes in order to aid male-female comparisons, as evidenced by a disaggregation by sex.
- In properly characterizing the socio-cultural context of the study area, better disaggregation of ethnicity is performed, including disaggregation by religion, which is (deliberately) neglected by the original syntax.
- Most importantly, a disaggregation by small-area (synthetic) zones is done in order to underscore the spatiality and context-sensitivity of the current study. Unlike the original MICS 5 indicators, the computation and mapping of small-area indicators is made possible by the synthetic micro-population derived from the SMM operation of this chapter.

Not only is the estimation of HIV/AIDS and sexual behaviour indicators in this chapter premised on the framework of social determinants of sexual behaviour and sexual health (Johnson *et al.*, 2005; Wellings *et al.*, 2006; Mmari and Sabherwal, 2013), these are also amongst the internationally adopted indicators for monitoring HIV/AIDS the world-over (UNAIDS and United Nations General Assembly Special Session on HIV/AIDS, 2007, 2008). In this regard, High-Risk Sexual Behaviours (H-RSB) are foregrounded (Abajobir *et al.*, 2017), such as sexual debut before the age of 18 years, sex with multiple partners, unprotected sex and transactional sex (Dunkle *et al.*, 2004). Thus, this approach is consistent with several studies that attribute the prevalence of HIV in sub-Saharan Africa to the preponderance of H-RSB in the region (Awad and Abu-Raddad, 2014; Delavande and Kohler, 2015; Lucas and Wilson, 2019). The definition of each of the estimated small-area MICS 5 indictors is as follows:

- **MICS 5 Indicator 9.1 (or MDG Indicator 6.3)**: Comprehensive Knowledge about HIV prevention among young persons. That is, persons of age 15 – 24 years who correctly identify ways of preventing the sexual transmission of HIV, and who reject major misconceptions about HIV transmission.
- **MICS 5 Indicator 9.4**: Persons who know where to be tested for HIV. That is, persons of age 15 – 49 years who state knowledge of a place to be tested for HIV.
- **MICS 5 Indicator 9.5**: Persons who have been tested for HIV and know the results. These are persons of age 15 – 49 years who have been tested for HIV in the last 12 months and who know their results.
- **MICS 5 Indicator 9.6**: Sexually active young persons who have been tested for HIV and know the results. These are young persons of age 15 – 24 years who have had sex in the last 12 months, who have been tested for HIV in the last 12 months and who know their results.
- **MICS 5 Indicator 9.12**: Multiple sexual partnerships. That is, persons of age 15 – 49 years who had sexual intercourse with more than one partner in the last 12 months.
- **MICS 5 Indicator 9.13**: Condom use at last sex among people with multiple sexual partnerships. That is, persons of age 15 – 49 years who report having had more than one sexual partner in the last 12 months who also reported that a condom was used the last time they had sex.
- **MICS 5 Indicator 9.14**: Sex with non-regular partners. That is, sexually active persons of age 15 – 24 years who had sex with a non-marital, non-cohabitating partner in the last 12 months.
- **MICS 5 Indicator 9.15**: Condom use with non-regular partners. That is, persons of age 15 –24 years reporting the use of a condom during the last sexual intercourse with a non-marital, non-cohabiting sex partner in the last 12 months.

5.3 The Spatial Microsimulation Modelling Procedure

The analytical procedure for developing a spatially-enriched synthetic population and the resulting small-area estimation of select health-relevant indicators follows standard SMM procedure summarized by Clarke and Harding (2013), as illustrated in Figure 5-2 below. The software used for preparing the input data for the SMM are ArcGIS Desktop 10.5, IBM SPSS v26 and Microsoft Excel 2016. The microdata was prepared using IBM SPSS v26 and Microsoft Excel 2016. All three software were used to prepare the spatial constraints. The Flexible Modelling Framework (FMF) v1.3 software was used to simulate a generalized synthetic micro-population of the study area, which was then used for the small-area estimation of relevant MICS 5 indicators (Harland, 2013). The FMF software is a mature spatial microsimulation software (Lovelace and Dumont, 2016, p. 10), as well as the most user friendly of the available options. The FMF v1.3 software was downloaded from https://github.com/MassAtLeeds/FMF/releases/tag/v1.3. Other specialist software for implementing SMM are outlined in Appendix A.3.2.

5.3.1 Preparing the Microdata/Population

Only respondents from Kogi State are included in the microdata, although SMM allows the use of microdata from a wider geographic area (and collected at different times) than that which is being modelled (Moon *et al.*, 2007; Smith *et al.*, 2009). Relevant variables of the microdata were recoded accordingly to match the configuration of the available spatial constraints. For instance, since only two categories of socioeconomic status are provided by spatial constraints (namely, Poor and Not Poor), the wealth index quintile of the microdata was regrouped into two corresponding categories. 'Poorest' (1) and 'Second' (2) were regrouped as 'Poor'; while 'Middle' (3), 'Fourth' (4) and 'Richest' (5) were regrouped as 'Not Poor'. Similarly, the multiple levels of education present in the MICS 5 survey microdata were regrouped into two, as 'Educated' and 'Uneducated' to match available spatial constraints. The selected variables and structure of recoded microdata used as linkage variables are outlined in Table 5-1. In the microdata, only respondents of age 15 – 49 years with all the relevant linking variables are included in the SMM operation in order to minimize modelling errors. Thus, the input MICS 5 microdata contain 1305 persons, comprising 912 females and 393 males.

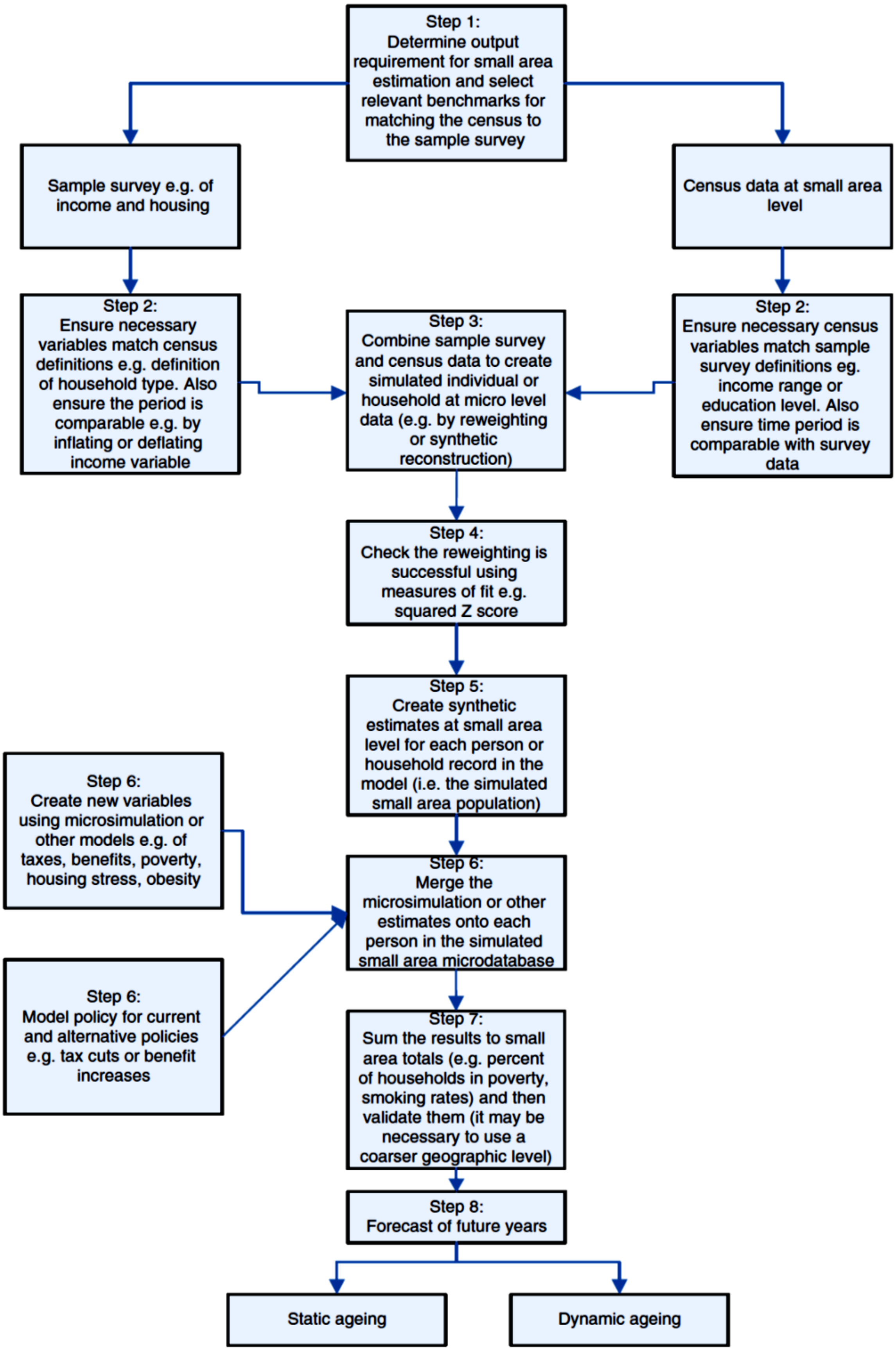


Figure 5-2 Overview of steps required to construct a spatial microsimulation model (Clarke and Harding, 2013, p. 262)

5.3.2 Preparing the Spatial Constraints

The small-area spatial constraints are the population attributes which were aggregated by synthetic analytical wards derived with the aid of the WorldPop gridded demographic data, as discussed in Chapter 4. Some WorldPop grids are also used to derive the spatial constraints and sub-constraints for this study. These are: age/sex structure, education (per sex) (as illiteracy ratio) and poverty. From the age/sex structure grid, three (3) spatial constraints were derived, namely: age (5-year groupings), sex (female or male) and 5-year age groupings by sex. From the education grid, two (2) spatial constraints were derived, namely: education (educated or uneducated) and education by sex (i.e. educated female, uneducated female, educated male or uneducated male). The poverty grid produced one spatial constraint, poverty (i.e. poor or not poor). It is worth mentioning that the illiteracy ratio provided by the WorldPop™ is for people of age 15 – 49. Therefore, the SMM implemented in this chapter is for people of age 15 – 49 years so as not to introduce many errors into the modelling process, especially during the validation stage of the synthetic population.

WorldPop's Age/Sex structure grids (i.e. the 'Population' grid described Section 4.2.1) provide population count per 1 km^2 pixel (at the equator), disaggregated by 5-year age groups and sex. Therefore, the ArcGIS 'Zone Statistics as Table' tool was used to compute the population count per small-area zone, using the summation operation. About 28 WorldPop grids depict age/sex structure per year; therefore, the process of computing the population count disaggregated by age and sex per small-area polygon was automated using a bespoke geoprocessing model (and an associated ArcTool) shown in Figure 4-3. WorldPop's literacy and poverty grids provide relevant ratios per 1 km^2 pixel (at the equator), with literacy disaggregated by sex. The same ArcGIS 'Zone Statistics as Table' tool was used to compute the literacy and poverty ratios respectively per small-area zone, using the 'mean' operation. These ratios were then used to determine the number of literate (per sex) and poor persons based on the population count in each small-area zone. The computation of literacy and poverty ratios requires the processing of three (3) WorldPop Grids. This process was also automated using the bespoke geoprocessing model (and an associated ArcTool) shown in Figure 4-4. In sum, the configuration of the variables used for linking the microdata with the spatial constraints of the SMM operation in this thesis is outlined in Table 5-1.

Most processes of data preparation for SMM involve the categorization of continuous variables or recoding of variables with many classes into fewer classes. In addition, it is sometimes necessary to use a subgroup of the study population, such as people of age 15 – 49 years in the current study. Though necessary for model execution, error mitigation and model validity, data preparation often results in a loss of nuance and the consequent reduction in the robustness of the derived synthetic population.

Table 5-1 The spatial constraints used in the SMM of Kogi State synthetic population (of persons age 15 – 49 years)

Spatial Constraint	Sub-Constraints	
Age (years)		
	15 – 19	35 – 39
	20 – 24	40 – 44
	25 – 29	45 – 49
	30 – 34	
Sex		
	Female	Male
Education		
	Educated	Uneducated
Poverty		
	Poor	Not Poor
Sex by Education		
	Female Educated	Male Educated
	Female Uneducated	Male Uneducated
Sex by Age		
	Female 15 – 19	Male 15 – 19
	Female 20 – 24	Male 20 – 24
	Female 25 – 29	Male 25 – 29
	Female 30 – 34	Male 30 – 34
	Female 35 – 39	Male 35 – 39
	Female 40 – 44	Male 40 – 44
	Female 45 – 49	Male 45 – 49

5.3.3 Implementing a SMM of Kogi State: Combinatorial Optimization (CO)

As discussed in Section 3.3.2, the CO type of SMM illustrated in Figure 3-3 requires two (2) types of appropriately structured data inputs; namely: spatial constraint files and a microdata/population file. With these, the SMM operation in this chapter is performed using the FMF v1.3 software, following the detailed users' guide of Harland (2013). The same process can also be implemented in R following the comprehensive guideline by Lovelace and Dumont (2016). With the FMF v1.3 software, this involves registering the constraint files and microdata file on the software and then creating the necessary linkage between these two groups of data, as shown in Figure 5-3. Other relevant parameters are then set on the software accordingly before running the simulation to produce the requisite synthetic population for the study area. Using SPSS v26 software, the extensive population attributes from the original sample survey microdata files are then joined to the raw output from the FMF software to create a comprehensive synthetic population of the study area. This is a typical instance requiring the 'Star join' command, which completes a one-to-many attributes join operation.

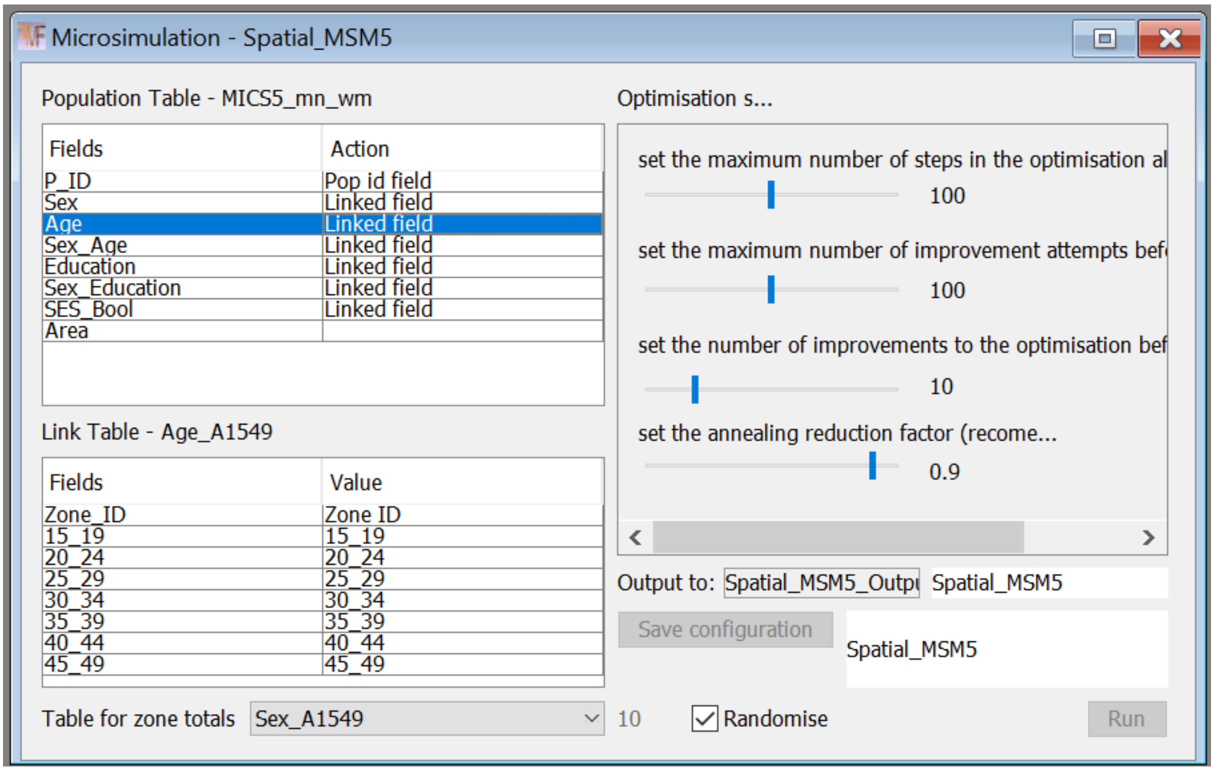


Figure 5-3 The SMM configuration (in the FMF software) for creating the synthetic micro-population of persons age 15 – 49 year in Kogi State, Nigeria.

The execution of the SMM within the FMF software environment is a computing-intensive process which took about 53 minutes of computer processing time[59]. The result is a synthetic population of 2,249,170 microunits (i.e. persons of age 15 – 49 years in the study area) comprising 1,115,283 females and 1,133,887 males, with about 425 MICS 5 attributes. The synthetic small-area analytical zone to which each synthetic person belongs is also included as a column of the resulting table. With the derived spatially-enriched synthetic population, it becomes possible to compute and map small-area estimates (of any MICS 5 indicator of interest) for the optimized analytical zones of this thesis. The goodness-of-fit of the derived synthetic population is examined in Appendix A.1.3, while the small-area estimates derived from the synthetic population are presented and discussed in Section 5.4 that follows.

[59] The computer uses a 7^{th} generation core i7 intel processor @ 2.70GHz, 8 GB RAM and a class 40 Solid State Drive.

5.4 Small-Area Estimates of Select MICS 5 Indicators of HIV/AIDS and Sexual Behaviour

In this section, the synthetic micro-population derived from the SMM operation in the preceding section is used for the small-area estimation and mapping of select MICS 5 indicators relevant to the needs and utilization of HIV/AIDS-related services in the study area. In addition to the derived choropleth maps in Figure 5-4 and Figure 5-7, the estimated indicators are also disaggregated by relevant PROGRESS-related population attributes (Oliver *et al.*, 2008; O'Neill *et al.*, 2014; Chambers *et al.*, 2017, p. 15), as shown in Figure 5-5, Figure 5-6, Figure 5-8 and Figure 5-9. These outputs are discussed further in the subsections that follow.

5.4.1 Key HIV/AIDS Indicators for Young People: MICS 5 Indicators 9.1 and 9.6

Figure 5-4A shows the small-area spatial variation in MICS 5 indicator 9.1 (and MDG Indicator 6.3), which is a measure of comprehensive HIV/AIDS knowledge among young persons of age 15 – 24 years. The spatial pattern suggests that there are relatively more number of young persons within the middle horizontal strip of the study area who have comprehensive knowledge about HIV than people in the upper and lower flanks. It is not apparent why this is the case; however, better knowledge about HIV is likely to be associated with both urban dwelling and more education (Bärnighausen *et al.*, 2008; de Walque, 2009). More educational opportunities as well as urban-dwelling tend to be concentrated in the same horizontal middle strip of the study area. Nevertheless, the percentage of young persons with comprehensive HIV knowledge in the study area is generally low, ranging from 4% to 9%. This implies a need to improve HIV-related education in the study area.

In Figure 5-4B, the small-area spatial variation of MICS 5 indicator 9.6 is shown. It suggests that there is more HIV testing by sexually active young persons on the western side of the River Niger (and more variations in the same region). The percentage of young persons that have tested for HIV in the last 12 months and know the results range from 3.6% to 12.4% in the study area. Not only is this percentage very low, but places with exceptionally poor testing for HIV are also shown. While the study area will benefit from universal improvement in the coverage of HIV testing for sexually active young persons, localities with exceptionally low records of HIV testing (3.6% - 6.3%) should be targeted for prioritized provision of HIV testing services as well as awareness creation (Anderson *et al.*, 2017).

MICS 5 indicators 9.1 and 9.6 are further disaggregated socioeconomically for the study area, as presented in Figure 5-6. This shows that more young people in urban areas have comprehensive knowledge of HIV (about 12.6%) than those in rural areas (about 5.9%). Similarly, in the last 12 months, there has been much more HIV testing amongst sexually active young persons in urban areas (about 25.4%) compared to rural areas (about 5.8%). While this urban advantage is plausible for a number of reasons, including increased health literacy as well as better accessibility of HIV services (Kayeyi *et al.*, 2013; Kasirye, 2016), this indicates that rural areas should be given prioritized attention for HIV/AIDS-related interventions. Furthermore, higher educational level and wealth quintile are associated with remarkable increases in both indicators 9.1 and 9.6. Together with urban residence, wealth and education are key markers of advantaged socioeconomic status. As these have been shown to be greatly associated with better knowledge of, as well as more testing for HIV amongst young people, poor knowledge of HIV and a lack of HIV testing by sexually active young people can be considered matters of disadvantage in socioeconomic status. This supports studies which show that even though highly educated and/or well-off people are more likely to engage in risky sexual behaviours (such as keeping multiple sexual partners), they also tend to be both more health literate and practice safe sex, thereby being less prone to HIV infection than poor and/or less educated people (de Walque *et al.*, 2005; Bärnighausen *et al.*, 2008; de Walque, 2009). Theoretically, there is a complex relationship between risky sexual behaviours and both schooling and wealth, which also varies by gender (Lucas and Wilson, 2019). Nevertheless, the spatial and social disaggregation of these indicators suggests socio-spatial inequalities that are worth investigating further in subsequent studies.

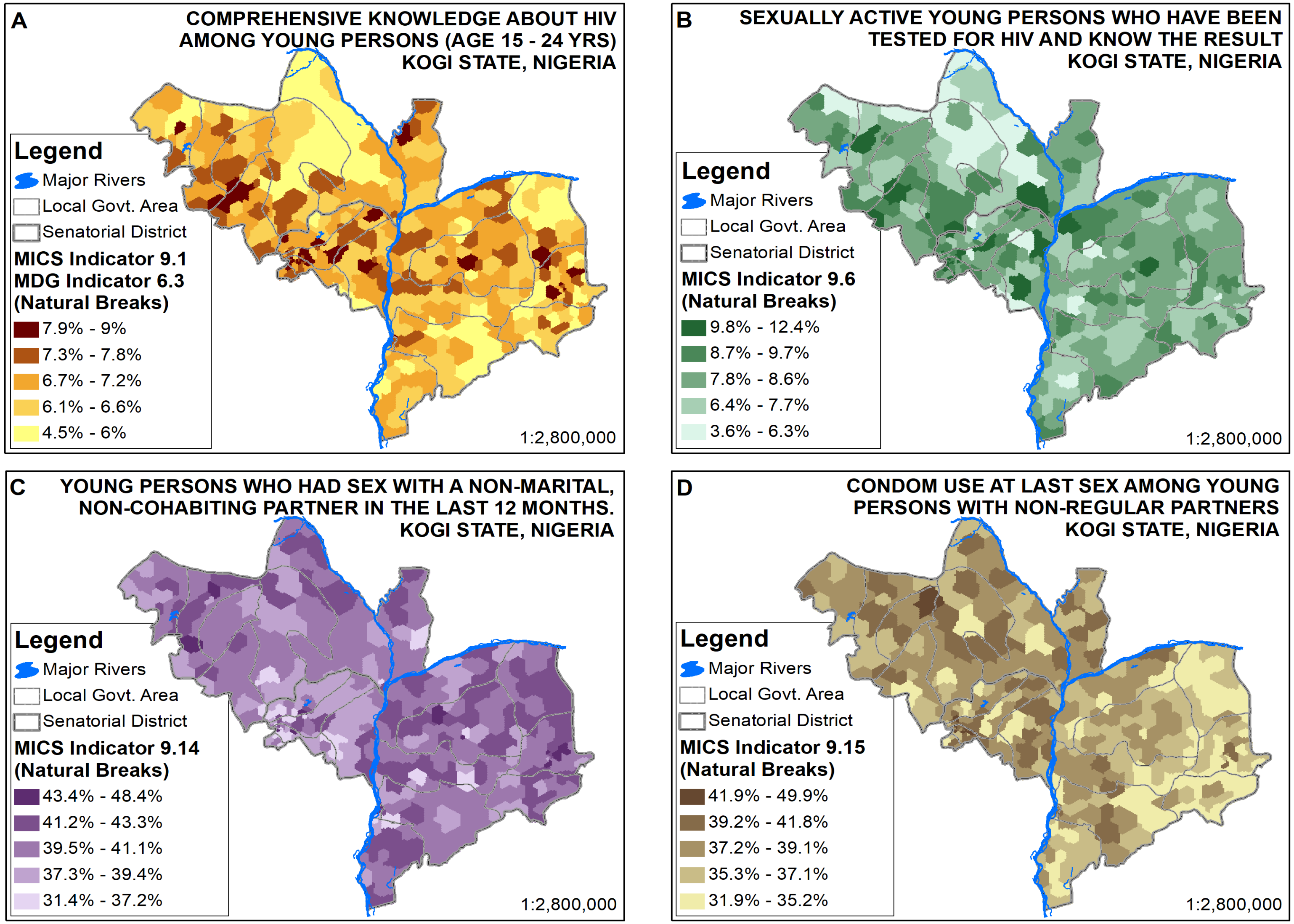


Figure 5-4 Small-Area variations in key HIV/AIDS and Sexual Behaviour Indicators of MICS 5 (Persons age 15 - 24)

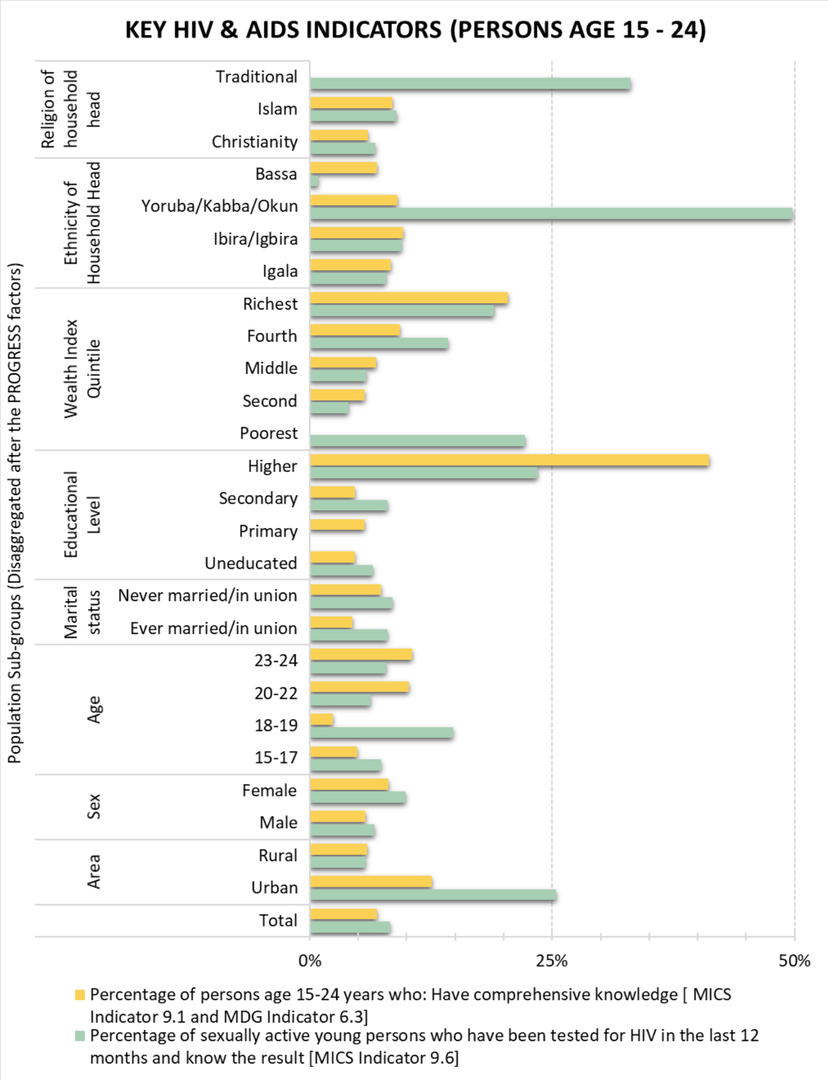


Figure 5-6 Key HIV/AIDS indicators for young persons disaggregated by relevant PROGRESS factors

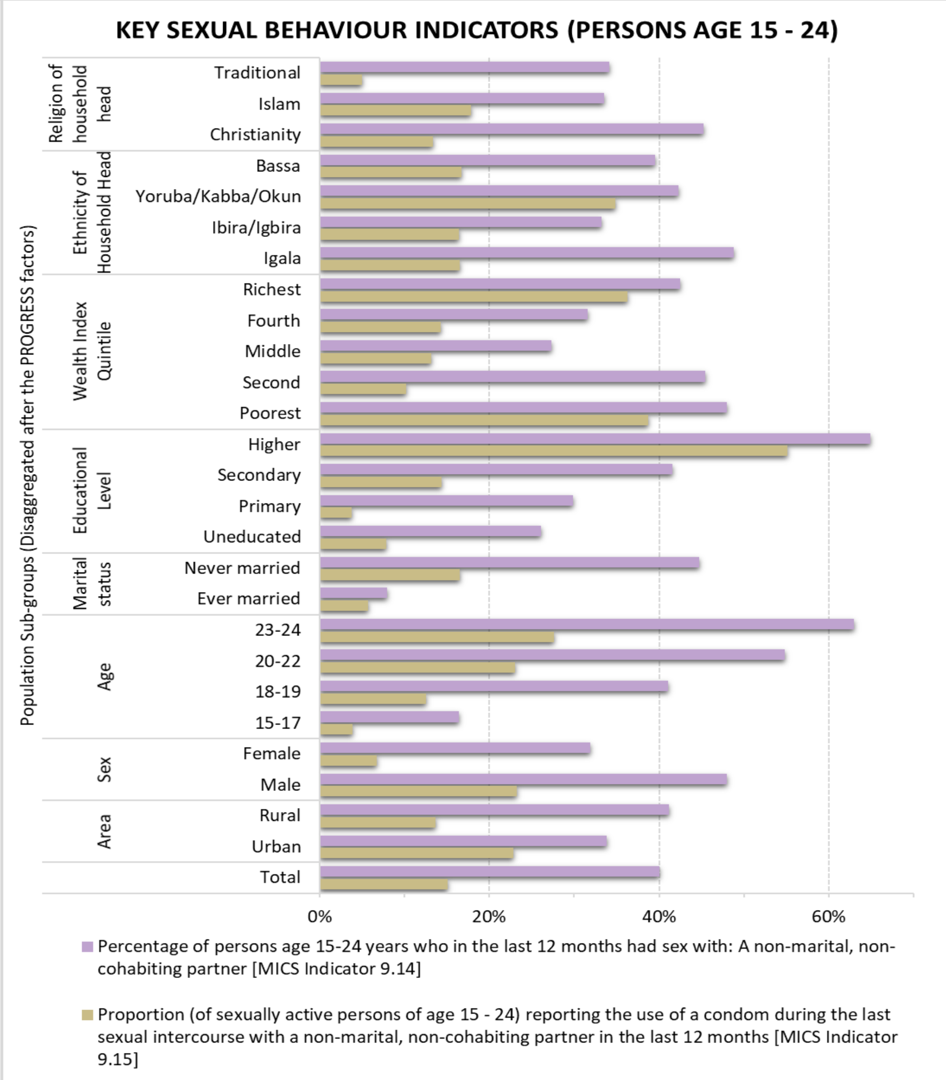


Figure 5-5 Key sexual behaviour indicators for young persons disaggregated by relevant PROGRESS factors

5.4.2 Key Sexual Behaviour Indicators for Young People: MICS 5 Indicators 9.14 and 9.15

The percentage of multiple sexual partnerships among young people (i.e. MICS 5 indicator 9.14) in Kogi State range from 31.4% to 48.4%, whereas 31.9% to 49.9% of this population used a condom during last sex with a non-regular partner (i.e. MICS 5 indicator 9.15). This is shown in Figure 5-4C and Figure 5-4D respectively. Although a large proportion of the young population in the study area had multiple sexual partners in the last 12 months, a good percentage of these used a condom in their last sexual intercourse with a non-regular partner. However, the observed spatial patterns in Figure 5-4C and Figure 5-4D suggest an inverse relationship between multiple sexual partnerships and condom use amongst young persons in the study area. For instance, relative to other senatorial districts, a smaller proportion of young persons in Kogi Central have multiple sexual partners, while a greater percentage of them report using a condom at last sex with a non-regular partner. Conversely, Kogi East, which records a high proportion of multiple sexual partnerships among young people, is also the senatorial district with a relatively low proportion of condom use at last sex with a non-regular partner. This indicates that although there is a need to improve sex education and HIV/AIDS-related healthcare/screening services in the study area, this is particularly more crucial in Kogi East to ensure that the higher proportion of multiple sexual partnerships is matched with safe sex practices.

MICS 5 indicators 9.14 and 9.15 are further disaggregated according to relevant socioeconomic markers, as shown in Figure 5-5[60]. With higher levels of education come increased proportions of young people reporting having had sex with multiple sexual partners in the last 12 months. For instance, 64.9% of young people with higher education reported having sex with a non-regular partner in the last 12 months, compared to 29.9% of young people with primary education reporting a similar practice. Nevertheless, this increased sexual partnerships associated with higher levels of education is also matched with more reports of regular usage of condoms (de Walque *et al.*, 2005; Kasirye, 2016). In fact, 84.8% of this population used a condom during their last sexual affair with a non-regular partner, compared to the 12.6% of young people with primary education who reported using a condom during a similar sexual affair. This shows that although more educated young people tend to be more

[60] Indicator 9.15 is depicted relative to Indicator 9.14 such that the golden bars have percentages that are independent of the y-axis of the chart, but relative to the purple bars (of indicator 9.14) in order to be more meaningful and aid proper comparisons.

exploratory at having sex with multiple sexual partners, they are also more cautious in practicing safe sex (by using a condom with non-regular partners) compared to their less-educated peers (Uchudi *et al.*, 2012, p. 291; Kayeyi *et al.*, 2013). This suggests a need for more sex education for young people with secondary education and lower. For young people of age 15 – 24, a key reason for increased multiple sexual partnerships with higher education is that time in higher education and beyond is often associated with more liberty/autonomy, being away from the restrictions of parents or guardians (Pilgrim *et al.*, 2014; Somefun and Odimegwu, 2018). Apparently, the educational level of young people is likely to be directly correlated with age. Results show that with increased age comes more tendency for sex with multiple sexual partners amongst young people; however, a greater proportion of non-teenage young people (42.1% and 43.8% for ages 20 – 22 and 23 – 24 respectively) reported using a condom at their last sexual affair with a non-regular partner compared to the proportion of teenage young people (23.5% or 30.6% for ages 15 – 17 and 18 – 19 respectively) reporting condom use. This is consistent with extant empirical literature, which suggests that awareness of safe sexual practices is positively related to age, education and socioeconomic status (Uthman *et al.*, 2013). As with having higher level of education, post-teenage young people are likely to be more autonomous than teenage young people, since they may no longer be subject to as many parental restrictions as teenagers (Pilgrim *et al.*, 2014; Somefun and Odimegwu, 2018). Despite this, they tend to be twice more likely to practice safe sex than teenage young people. Thus, teenage young people should be prioritized for HIV-related interventions, especially on the need for safer sexual behaviour.

Other interesting patterns are also observable when Indicators 9.14 and 9.15 are disaggregated according to marital status, sex, and urban/rural dwelling. Being in non-committal relationships, much more single young people (44.7%) have had sex with multiple sexual partners in the last 12 months compared to their married peers (7.9%), as expected (Marston *et al.*, 2009; Żaba *et al.*, 2009). Furthermore, amongst married young people who have had an extra-marital sexual partner in the last 12 months, a large majority (72.2%) recorded using a condom, compared to the proportion of single young people that recorded using a condom with their non-regular sexual partner in the same period (36.8%). For cultural and religious reasons, married young people in the study area are much less likely to engage in extramarital sex compared to their single peers (Olivier and Wodon, 2015). Moreover, having a married regular sexual partner means that most married young people are not likely to be keenly searching for new sexual partners. Whenever such extramarital affairs happen, condoms are often used to prevent both pregnancy of the non-regular (female) partner as well as the transmission of an STI/STD to their married spouse.

It is not surprising that more proportion of young males have had sex with a non-regular sexual partner (48.0%) compared to the proportion of females with multiple sexual partners in the last 12 months (31.9%) (Bamidele *et al.*, 2007; Romero-Estudillo *et al.*, 2014; Somefun, 2019). This is because Nigeria, like many sub-Saharan African countries, is notoriously patriarchal, thus culpable of hegemonic masculinity (Hearn and Morrell, 2012; Jewkes *et al.*, 2015; Messerschmidt, 2018). This concept develops on ideas of patriarchy in explaining entrenched patterns of social practices (including actions and expectations) that perpetuate male dominance of females, often facilitated by culture, institutions and political influence (Connell and Messerschmidt, 2005, p. 832). Consequently, while females are highly discouraged from keeping multiple sexual partners for cultural reasons, males do not experience the same levels of restrictions even when married (MacPhail, 2003; Bowleg *et al.*, 2011). Indeed, in many localities (including the study area), while it is a taboo for married females to engage in extramarital sex, this is not the case for married males. It is however ironical that a higher proportion of married young males who reported having sex with a non-regular partner in the last 12 months (48.4%) indicate using a condom in such affairs, compared to the percentage of their female peers who reported using a condom in their last sexual affair with non-regular partners (21.0%) (Ahmed *et al.*, 2001; Wellings *et al.*, 2006, p. 1714; de Walque and Kline, 2011). This may be because, in the study area, there is a tendency for (married) females who have sex with non-regular partners to do so for a variety of transactional reasons (including in exchange for gifts or other favours from men), in which case, they are less able to negotiate for safe sex (Soler *et al.*, 2000; Dunkle *et al.*, 2004; Ramjee and Daniels, 2013). Consequently, young males are twice more likely to practice safe sex with a non-regular partner than females, thereby partly explaining why young females (of age 15–24 years old) in sub-Saharan Africa are twice as likely as young males to have HIV (UNAIDS, 2014, p. 20). This suggests a need to promote safer sexual practices amongst young people, especially females, as well as target empowerment interventions at women to make them less vulnerable (Lucas and Wilson, 2019, p. 2189).

In rural areas, more young people report having sex with a non-regular partner (41.1%) in the last 12 months, compared to their peers in urban areas who reported a similar practice (33.9%) (Oyediran *et al.*, 2011). This suggests that young people in rural areas enjoy more autonomy than their peers in urban centres, probably because of the very informal and communal nature of rural areas in the study area. With this comes increased risk of HIV infection because people who become sexually active at a younger age are more prone to having multiple sexual partners in their lifetime, which is associated with a higher tendency for indulging in other risky sexual behaviours (de Walque *et al.*, 2005; Marston *et al.*, 2009). This is, however, a little at conflict with the patterns recorded based on disaggregation by educational level because more proportion of young people in urban areas are expected to possess higher education compared to their peers in rural areas. Despite more reports of having had sex with non-regular partners amongst young people in rural areas, a much lower proportion of these people do not use condoms compared to their peers in urban areas (Oyediran *et al.*, 2011). While 67.5% of young people with multiple sexual partners in urban areas used a condom during last sex with a non-regular partner, only 33.3% of young people in rural areas reported condom use. Hence, young rural dwellers are twice less likely than their urban peers to practice safe sex with a non-regular partner. In addition to poorer access to condoms in rural areas, this could indicate lower levels of sex education and, by extension, less awareness of safe sex practices compared to urban areas (de Walque, 2009; Kayeyi *et al.*, 2013). On the one hand, this suggests a need for increased sex education, condom accessibility and the promotion of safe sex practices in rural areas. On the other hand, being more vulnerable, rural areas should be targeted for increased accessibility to medical services related to the sexual health of young people, such as HIV/AIDS-related services as well as services for other STD/STIs, such as relevant screenings/tests (Nompumelelo *et al.*, 2004, p. 34; Anderson *et al.*, 2017).

5.4.3 HIV Testing and Knowledge of Where to get Tested: MICS 5 Indicators 9.4 and 9.5

Of people age 15 – 45 years in the study area, 21.7% to 44.5% in various localities (i.e. synthetic wards) know where to get tested for HIV, as shown in Figure 5-7A. Furthermore, more people in urban areas know where to get tested compared to people in rural areas. For example, higher proportions (37.5% to 44.5%) can be seen around Anyigba, Ankpa, Idah (which are the three main towns in Kogi East) as well as in Lokoja, Okene, Ogori and Kabba towns. In the study area, urban dwellers tend to be both more educated and of higher socioeconomic status than rural dwellers. This, in addition to the typical concentration of medical facilities in urban areas, greatly privileges urban dwellers in terms of knowledge of where to get tested (Nompumelelo *et al.*, 2004, p. 34). This calls for a need to improve the accessibility of HIV testing facilities as well as making the rural population aware of available HIV testing centres.

As expected, the spatial pattern of people who have been tested for HIV shown in Figure 5-7B is very similar to the pattern of people who know where to get tested, as shown in Figure 5-7A. For without the knowledge/awareness of where to get tested for HIV, there cannot be the actual testing. This also supports the inclusion of awareness as a dimension of access, as discussed further in Chapter 7 (Saurman, 2016). Nevertheless, not everyone who knows a testing place has been tested, as only 5.5% to 14.3% of sexually active people (of age 15 to 45 years) in the study area have been tested for HIV in the last 12 months, and know the result; whereas 21.7% to 44.5% know where to get tested. While it is necessary for more people to be encouraged to get tested for HIV as a first step to curtailing the HIV endemic in LMICs like the study area, these efforts should be prioritized in localities with the least record of HIV testing, as shown in Figure 5-7B. This type of intervention may also entail the provision of HIV testing services in localities with a lack of spatial accessibility, especially in isolated rural communities, which are often at a disadvantage in healthcare services provision.

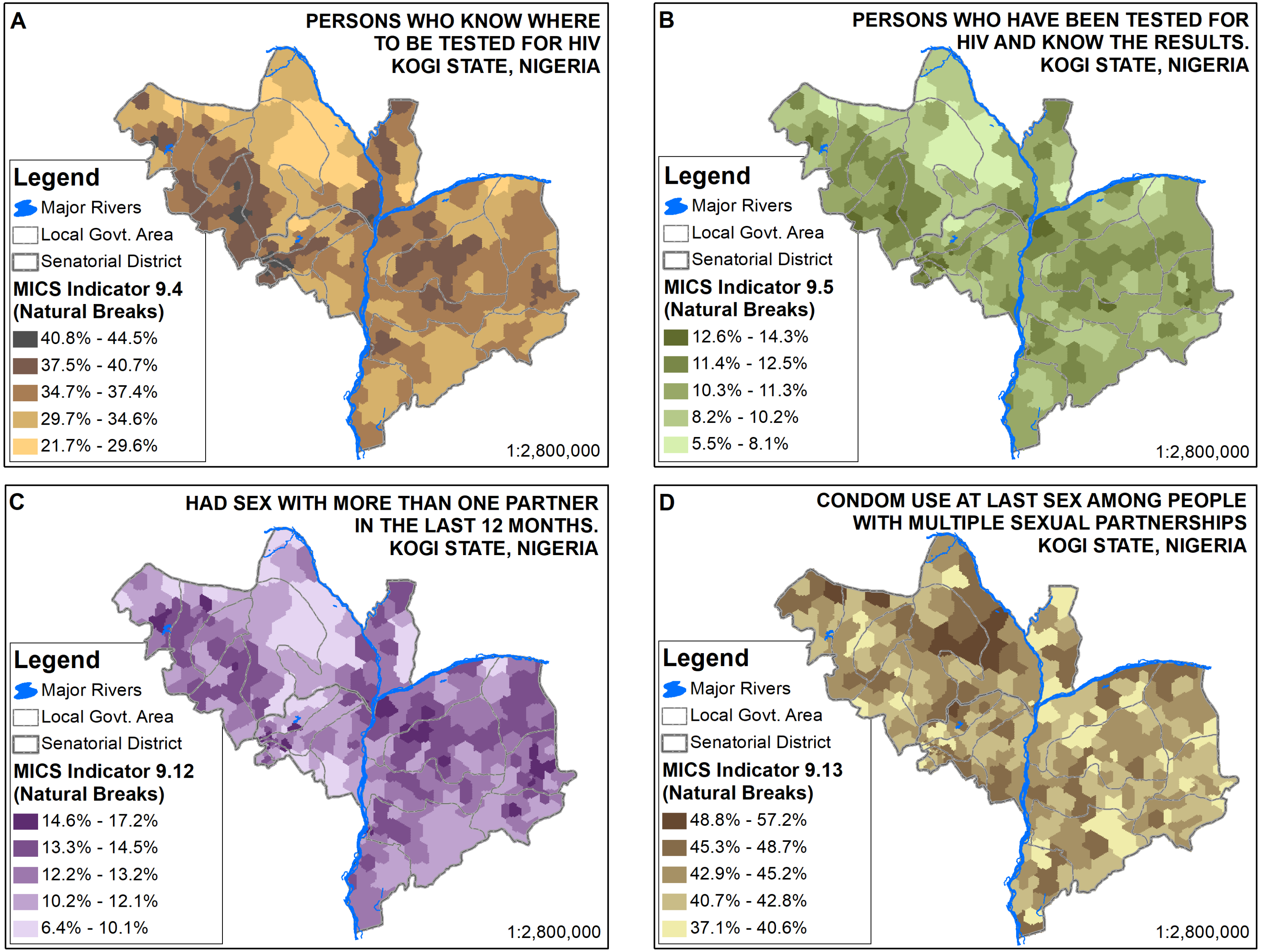


Figure 5-7 Small-Area variations in key HIV/AIDS and Sexual Behaviour Indicators of MICS 5 (for persons age 15 – 49)

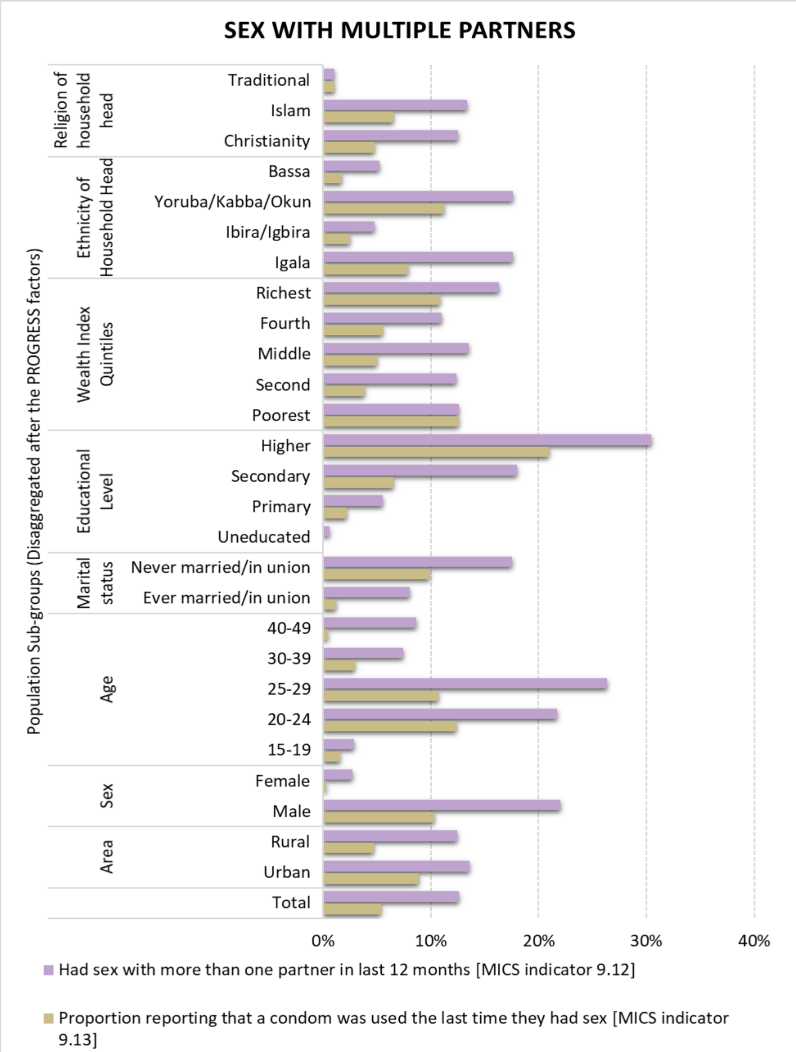


Figure 5-8 Sex with multiple partners and condom use by people age 15 – 49 years disaggregated by relevant PROGRESS factors

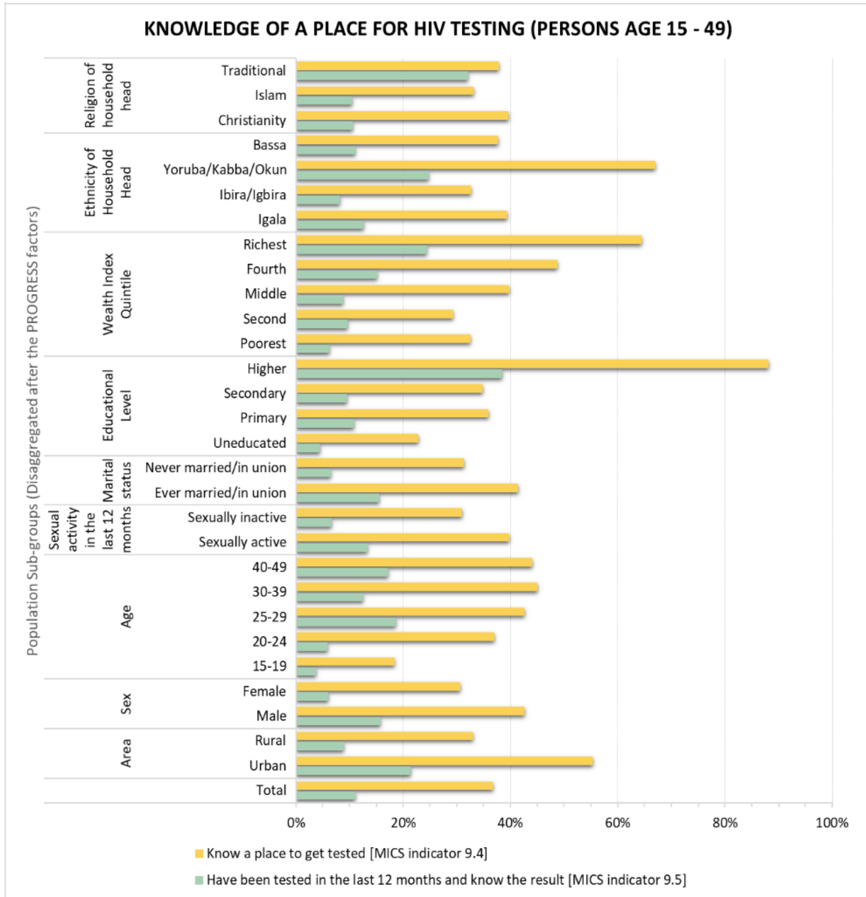


Figure 5-9 Knowledge of a place for HIV testing by people age 15 – 49 years disaggregated by relevant PROGRESS factors

Similar to the spatial disaggregation of MICS 5 Indicators 9.4 and 9.5 by small-area analytical zones shown in Figure 5-7A and B respectively, a disaggregation by relevant PROGRESS factors (in Figure 5-9) suggests that with increasing knowledge of where to get tested for HIV comes an increase in the proportion of HIV testing across all the socioeconomic and demographic classes considered. As with MICS 5 Indicators 9.1 and 9.6 (shown in Figure 5-6 and discussed in Section 5.4.1), there are remarkable patterns based on wealth index quintile, educational level, age, marital status, sex, urban/rural area as well as being sexually active or not in the last twelve months. Based on the wealth index quintile, there is a positive association between wealth and knowledge of where to get tested as well as having been tested in the last 12 months. While 32.6% of the poorest quintile (of people of age 15 – 49) know where to get tested for HIV, 64.5% of the richest quintile know where to get tested. Similarly, 24.4% of the richest quintile were tested for HIV (with known results) in the last 12 months, while only 6.3% of the poorest quintile have been tested. This suggests that the poorest quintile are four times less likely to be tested for HIV in the study area. This may be associated with the fact that socioeconomic advantage is usually connected with high levels of education as well as urban residence, both of which also show remarkably higher levels of both Indicators 9.4 and 9.5 (Kayeyi *et al.*, 2013; Kasirye, 2016). The literature also supports the idea that with more wealth comes more awareness and utilization of relevant healthcare services (Peters *et al.*, 2008; Cockerham, 2014c). This is also implied by the inverse care law (Tudor Hart, 1971, 2000).

From Figure 5-9, it can also be seen that higher levels of education are positively associated with more knowledge of HIV testing facilities as well as having been tested in the last 12 months . People (of age 15 – 49) with higher education have both far more awareness of HIV testing facilities and have been tested in the last 12 months (de Walque *et al.*, 2005; Bärnighausen *et al.*, 2008; de Walque, 2009). For instance, while 88.2% of people with higher education know a place to get tested for HIV, only 22.8% of uneducated people have the same knowledge. Similarly, whereas 38.4% of people with higher education have been tested for HIV in the last 12 months, only 10.8% of people with primary education have received the same service. This implies that people with primary education are about four times less likely to have been tested for HIV in the last 12 months. This is not surprising because with increasing (i.e. higher) education comes more health literacy, personal efficacy, and health-seeking and utilization propensity (Grossman, 1972, 1982; Akinyemi, 2016). Not only are persons who have ever been married more aware of HIV testing facilities, but this group has also recorded more

HIV testing than single people. 41.5% and 15.5% of married people know where to get HIV tested and have been tested for HIV respectively, in the last 12 months, while 31.4% and 6.5% of unmarried people have the same knowledge and have received HIV testing respectively. While there is not much difference in knowledge of a HIV testing place (i.e. Indicator 9.4) based on marital status, married people are at least twice more likely to have been tested for HIV than unmarried people. This is not surprising because HIV testing is one of the standard requirements for most marriage formalizations in the study area. Furthermore, HIV testing is one of the standard healthcare services provided during antenatal care, whose recipients are likely to be married females. Associated with the foregoing is the fact that with marriage comes inevitable sexual activity. Hence, compared to sexually inactive people, more sexually active persons have reported both knowledge of HIV testing places and actual HIV testing in the last 12 months (39.8% and 13.3% respectively).

5.4.4 Multiple Sexual Partnerships and Condom Use: MICS 5 Indicators 9.12 and 9.13

Socio-spatial patterns of people who had sex with a non-regular partner in the last 12 months (Indicator 9.12), as well as the proportion reporting a condom use in the latest of such affairs (Indicator 9.13) are discussed in this section with reference to Figure 5-7(C and D), and Figure 5-8. As these indicators report sexual behaviour for the entire study population (people aged 15 – 49 years), some comparisons are made with Section 5.4.2, which reports similar sexual behaviour for only an age subgroup, people aged 15 – 24 years. The spatial patterns of indicators 9.12 and 9.13 are slightly similar to those exhibited by young people (of age 15 – 24 years) shown in Figure 5-4(C and D) discussed in Section 5.4.2. This implies that Kogi East maintains its lead at keeping multiple non-regular sexual partners while Kogi Central shows much less multiple sexual partnerships in the last 12 months. This supports the perspective that contextual factors, as well as cultural norms, are significant determinants of sexual behaviours (Sallis *et al.*, 2008; Benefo, 2010; Uchudi *et al.*, 2012, p. 292). Thus, in addition to educational level, wealth and urban/rural factors noted previously, societies with higher tolerance to sexual permissiveness and weak family institutions are positively associated with increased indulgence in risky sexual behaviours. However, the added consideration of people aged 24 to 45 years means that the proportion of people keeping multiple sexual partners has decreased in all the small-area zones of the study area. While the small-area values for indicator 9.12 range from 6.4% to 17.2% for the entire study population (i.e. people of age 15 – 45 years old), similar values for indicator 9.14 are much higher, ranging from 31.4% - 48.4%, as shown in Figure 5-4C. This attenuation effect is evident from Figure 5-8 in which the practice of having had sex with a non-regular partner (in the last 12 months) peaked for people of age 25 – 29 years and dropped drastically for people aged 30 years and older. Hence, while 26.3% of people aged 25 – 29 years had sex with a non-regular partner in the last 12 months, only 7.4% and 8.6% of people aged 30 – 39 and 40 – 49 years respectively indulged in the same practice. Not only does this suggest that the practice of keeping multiple sexual partners is preponderant with people under 25 years, this tends to align with the likelihood that people over 29 years old are married, and from the same Figure 5-8, married people are seen to be twice less likely to have sex with non-regular partners. 17.5% of unmarried people had sex with a non-regular partner while only about half of this proportion, 8.1% indulged in a similar practice in the last 12 months. Indeed, this is much to be expected because, for cultural reasons, it is immoral (and sometimes a consequential taboo) for married people to have extramarital sexual affairs, especially for married females. Nevertheless, in contrast with Section 5.4.2 (Figure 5-4D), people reporting the use of condoms during their last sex with a non-regular partner increased from between 31.9% – 49.9% (of the young population) to between 37.1% – 57.2% (for the entire study population). The factors that underpin or drive these socio-spatial patterns in sexual behaviour are not yet well understood; hence, this is a matter for further exploration, which is outside the scope of the current study. Nonetheless, spatial variations in potential explicators of sexual behaviour, such as education, age, cultural practices and religious inclinations across the various regions in the study area, are likely to explain these spatial patterns (de Walque *et al.*, 2005; Bärnighausen *et al.*, 2008; de Walque, 2009; Lucas and Wilson, 2019). In short, this corroborates Section 5.4.2 by confirming on the one hand that across all age groups, a greater proportion of people in Kogi East tend to indulge in risky sexual behaviour, compared to people in the two other senatorial districts, with fewer people in Kogi Central exhibiting unsafe sexual behaviour. Hence HIV/AIDS-related interventions should prioritize Kogi East.

On the other hand, this shows that people of age 25 – 29 years old are the most likely to exhibit risky sexual behaviour, with 26.3% having unprotected sex with non-regular sexual partners). This is more so that less proportion of this age group (40.7%) reportedly used a condom with their last non-regular sexual partner compared to the 57.2% who reportedly used a condom amongst the next younger age group (i.e. people age 20 – 24 years) with a preponderance of risky sexual behaviour. This is partly to be explained by findings that show that condom usage is most popular with various relationship types described as: short-term, occasional, casual or onetime; in contrast to long-term relationship types (Maticka-Tyndale, 2012, p. 64). In this regard, people aged 20 – 24 years are more likely to be in short-term relationships than people of age 25 – 29 years old. Not only does this support existing literature which suggests that younger people are more likely to use a condom than older people (Ahmed *et al.*, 2001; Adair, 2008), it also implies that HIV/AIDS-related interventions in the study area should not focus on only people categorized as young by the MICS indicator (i.e. people of age 15 – 24 years), but should extend to and in fact prioritize interventions for people of age 25 – 29 years, especially the unmarried.

In addition to the foregoing, from Figure 5-8, some other socioeconomic patterns of MICS 5 indicators 9.12 and 9.13 are worth discussing. The practice of having sex with a non-regular partner is more associated with young people (of age 15 – 24 years) who are unmarried, compared to the unmarried group of the entire study population. For example, the proportion of unmarried young people who had sex with a non-regular partner in the last 12 months is 44.7%, while for the entire study population (of age 15 – 49 years), only 17.5% reported a similar practice. On the one hand, this suggests that younger people are more adventurous or exploratory in keeping multiple sexual partners; on the other hand, this suggests that after 24 years of age, unmarried people tend to stick with one sexual partner to whom they hope to eventually get married. Being consistently low (7.9% or 8.1%), there is negligible difference in the tendency of married people to have sex with a non-regular partner, regardless of age. However, amongst married people, by far more proportion (72.2%) of young people (of age 15 – 24 years) report using a condom during sex with their last non-regular partner, compared to the 15.4% of married people across the entire study population that reported using a condom during the same sexual practice (de Walque and Kline, 2011). The question of why married people of ages 15 – 24 years are much keener on practicing safe sex during extramarital affairs compared to the entire study population is a matter for further exploration outside the scope of the current study.

Among unmarried people, condom usage during sex with non-regular partners does not show as much large a difference when young people (age 15 – 24 years) are contrasted with the entire population (of age 15 – 49 years). However, in contrast to the sexual behaviour of married people, a lower proportion of young unmarried people (36.8%) report using a condom with their last non-regular sexual partner, compared to the 56.3% of unmarried people of the entire study population who reported using a condom during a similar practice. This reiterates the notion that the practice of unsafe sexual behaviour is more common amongst young unmarried people, compared with all unmarried people in the study population. Nevertheless, young unmarried people are likely to use condoms for a variety of reasons, including: being the focus of HIV prevention interventions, being more likely to be in short term relationships, having more interest in postponing conception, and being more likely to be in school (Ross *et al.*, 2006; Kirby *et al.*, 2007; Cherutich *et al.*, 2008; Kabiru and Orpinas, 2009; Enuameh *et al.*, 2011).

Similar to indicators 9.14 and 9.15 which are concerned with only young people of age 15 – 24 years, Figure 5-8 shows that with higher levels of education come increases in both indicator 9.12 and 9.13. In other words, with more education, more people tend to both have sex with non-regular partners and use a condom during such affairs (Bärnighausen *et al.*, 2008; de Walque, 2009; Maticka-Tyndale, 2012). However, across all educational levels, the ratio of young persons who had sex with a non-regular partner in the last 12 months is more than the ratio who recorded a similar practice for the entire population. For instance, 30.4%, 18.0% and 5.6% of people with higher education, secondary education and primary education respectively recorded having sex with a non-regular partner in the last 12 months. Of these, 68.7%, 36.2% and 39.5% of people with higher education, secondary education and primary education respectively reported using a condom during sex with their last non-regular partner. Hence, as with the pattern of sexual behaviour discussed in Section 5.4.2 for only young people, with higher levels of education come more practices of sex with a non-regular partner. However, this practice is matched with equally higher usage of condoms compared with people of lower levels of education (Adair, 2008).

5.5 Implications and Benefits of Population Synthesis for Small-Area Estimation

A cardinal objective of the UHC agenda (of the SDGs) is a reduction of inequalities in access to and utilization of primary healthcare services, with the overall expectation that this leads to improved health outcomes for everyone, without leaving vulnerable or disadvantaged population subgroups behind. To accomplish this, it is well-established that SDG-related data must be disaggregated socioeconomically and spatially, following the PROGRESS stratifiers (O'Neill *et al.*, 2014; Freistein and Mahlert, 2016; UNDP, 2018). In pursuit of this goal of ‘leaving-no-one-behind’, there has been robust socioeconomic data disaggregation in many works. However, most existing attempts at spatial data disaggregation using national household survey data are only able to differentiate between urban and rural areas or large subnational zones. This level of spatial disaggregation is grossly deficient, not least because it implicitly assumes that all rural or urban areas (or large subnational zones) are homogeneous, which clearly is untenable. While this level of data disaggregation is useful for directing/targeting (inter)national interventions to needy countries and large subnational regions, they are poor at pinpointing specific localities within countries/regions wherein relevant interventions are most needed (Leyk *et al.*, 2013; Rahman and Wazed, 2018; Eslava-Schmalbach *et al.*, 2019). This realization motivates the need for finer levels of spatial disaggregation of health-(or SGD-) related indicators at subnational or preferably district levels, which also is in tandem with an increasing decentralization of the management of public sector primary healthcare services in many contexts (Johnson *et al.*, 2010; Sridhar, 2016). District Health Strengthening Systems (DHSS) require that decision making as well as the implementation of UHC policies and strategies are localized to district levels. To this end, not only is it necessary to develop new ways of data collection, but it is also crucial to increase the precision of data to be able to track small-area trends in healthcare access and utilization, as well as to expand our understanding of the multitude of factors that deter or facilitate healthcare access and utilization in various localities (O’Connell *et al.*, 2015). While the former has been effectively accomplished in this chapter with the aid of SMM, it also serves as the groundwork for realizing the latter using the derived synthetic population.

In addition to the estimation of relevant small-area indicators of MICS 5, this chapter provides the framework for establishing different types of connections between sample survey microdata and other spatial healthcare variables (like spatial accessibility), using the synthetic individual-level population derived from SMMs. For instance, the demographic details in the Sample Survey Microdata can be linked with the small-area spatial accessibility of select healthcare services using appropriate ‘join’ operations with a view to exploring socioeconomic determinants of spatial accessibility, among other things. The synthetic population micro-units can also be assigned to their appropriate healthcare facilities (using either a huff model or a proximity method, i.e. a catchment area analyses), after which the attributes of the healthcare facilities within each catchment can then be linked to their respective catchment population in order to explore interrelationships between catchment demographics and healthcare quantity or quality (using appropriate regression models). This approach of linking SMMs with other macro- or meso-scale models is exemplified by Morrissey *et al.* (2013a; 2013b, p. 6), and has been identified as a 'fascinating new area for research' (Clarke and Harding, 2013; Tanton and Edwards, 2013b).

5.6 Summary and Conclusion

Spatial Microsimulation is the only method for small-area estimation that is explicitly geographical (Rahman and Harding, 2017). Through the simulation of a spatially enriched synthetic population, it enables the small-area spatialization of variables available in sample survey microdata. Therefore, it is an invaluable method for conducting policy-relevant research comprising both social and spatial dimensions. Consequently, it lends itself very well to the study of socio-spatial inequalities in many application domains, including health(care), poverty, and education (Ballas *et al.*, 2006; Kavroudakis *et al.*, 2013; Campbell and Ballas, 2016; Panori *et al.*, 2017). SMM is also well suited for use in conjunction with other mesoscale models like SIMs and L-A models (Tomintz *et al.*, 2008; Morrissey *et al.*, 2013a, 2013b).

A major contribution of this work is that while all existing works on SMM use extant census geographies as their small-area constraints, this work simulates a synthetic population for bespoke optimized small-area zones created from a sophisticated Automatic Zone Design (AZD) procedure. This type of implementation embodies the additional challenge of determining multiple spatial constraints for the bespoke small-area analytical zoning system. These constraints are derived from relevant WorldPop gridded demographic data, making this work the first (that the author is aware of) to utilize an unconventional non-census data source for SMM. In short, the work completed in this chapter makes it possible to produce reliable detailed estimates of relevant population attributes for small-area zones of various shapes and sizes, effectively emancipating the researcher from the problems of extant census/administrative zoning systems. This effort effectively opens a myriad of opportunities for applying the extensively policy-relevant methodology of spatial microsimulation in the global south, which is often characterized by severe data scarcity.

In this chapter, eight (8) MICS 5 indicators relevant to the assessment of small-area need and utilization of HIV/AIDS-related healthcare services in the study are estimated, mapped, disaggregated socio-demographically and then analyzed. The number of sexually active persons per synthetic ward is one of the intermediate outputs of these MICS 5 Indicators which serve as a precise need variable for analyzing the small-area accessibility of family planning services in Chapter 6. Congruent with the standard practice for reporting SDG-related indicators, simple descriptive statistics (especially percentages and counts/frequencies) are used in explicating the HIV/AIDS and Sexual Behaviour themes of this chapter. This reporting convention is typically for easy comprehension by policymakers and the public, many of whom are not likely to be experts in statistics. Furthermore, the synthetic population developed in the chapter is amenable to other inferential and/or advanced statistical techniques like multiple regression and correlation (Morrissey *et al.*, 2013b, p. 138). It is worth noting, however, that because a synthetic population is being used in contrast to the population samples of typical surveys, many tests for the significance of findings become irrelevant (such as t-tests).

Standard socioeconomic and demographic disaggregation of relevant MICS 5 indicators provide insights for the entire country; however, this may not be representative of a sub-national context like the study area, Kogi State. The SMM estimations in this chapter provide a more plausible and representative context-specific version of the same MICS 5 indicators, thereby serving as an effective form of extrapolation. This facilitates an understanding of ecological factors that may mediate HIV/AIDS and sexual behaviours at multiple spatial scales in Kogi State, including small-areas (Uchudi *et al.*, 2012). These often ignored aspects of contextual factors include the effects of community infrastructural development, community access to condoms, community-level social norms or culture as well as population growth rate and density (Kimuna and Djamba, 2005; Benefo, 2010). Whereas the context-specific socio-economic disaggregation of this chapter has been performed for the entire study area, the same can be done for other inherent smaller geographies, such as senatorial districts and LGAs. While this demographic disaggregation is useful for social targeting of relevant interventions, estimated small-area attributes like HIV/AIDS-related sexual behaviours indicators (i.e. spatial disaggregation) are invaluable in spatially targeting relevant demand- and supply-side interventions in any context (Anderson *et al.*, 2017). For instance, localities needing more campaigns for the practice of safer sex are identified. Furthermore, these estimates are useful as potential demand variables for planning the supply and optimal spatial organization of HIV/AIDS-related services in the study area. This comprehensive socio-spatial disaggregation can also inform the design of potential qualitative data collection with a view to performing further intensive analysis, which develops/expands on the findings of the current study. Indeed, Chapter 7 aptly demonstrates this possibility, in part, in the context of this spatial MMR project.

One limitation with the Combinatorial Optimization algorithm used in this study is that meaningful spatial variations in the variable being estimated are provided only at the spatial scales of the constraints used. Aggregating these spatial constraints (i.e. small-area zones) onto larger higher-level zones does not produce meaningful spatial variations in the estimated variable. This suggests that to derive estimates of relevant population attributes for zones of various scales, multiple implementations of SMM have to be completed, with the requisite zones serving as the relevant spatial constraints for each case. Further limitations of SMM are discussed in Section 8.3.1.

Chapter 6. Modelling Small-Area Variations in Spatial Accessibility of Primary Healthcare Services

6.1 Background

The essence of this chapter is to characterize small-area variations in spatial accessibility of primary healthcare services in the study area, with a view to identifying MUA and HPSAs (Wang and Luo, 2005; Ricketts *et al.*, 2007). This agenda is the third research objective of this doctoral research project. Here, spatial accessibility is considered a subset of access (see Section 2.3.2), and is based on the pervasive spatial interaction theory of human geography (Fotheringham and O'Kelly, 1989; Fischer, 2006; Langlois, 2013; Morrissey, 2015). From this theoretical framework, spatial accessibility is an indicator of the degree of localized opportunity to utilize needed healthcare services, having accounted for travel-related disutility between demand and supply locations as well as the relationship/ratio between the quantity of supply and potential demand in a study area (Condeço-Melhorado *et al.*, 2014). By attempting to incorporate service agglomeration and attractiveness effects, this definition of spatial accessibility improves on the classical concept of 'potential spatial access' (Khan, 1992; Guagliardo, 2004).

This chapter builds on the theoretical and methodological reviews and discussions of spatial accessibility in Sections 2.3 and Section 3.3.3 respectively. Here, an advanced variant of the 2SFCA method, the ONN-G2SFCA introduced in Section 3.3.3.5, is used to analyze relevant data whose results are then discussed for the study area. In so doing, the standard framework for analyzing spatial accessibility is followed, as shown in Figure 3-4 (Liu and Zhu, 2004; Morrissey, 2015; Apparicio *et al.*, 2017). Thus, this chapter meets the third research objective of this thesis by answering the question: what are the small-area patterns of needs, availability and spatial accessibility of primary healthcare services in the study area? The methods of data analysis for answering this question is the subject of the next section. A detailed map of the study area which complements Figure 1-1, is provided in Figure 6-1 to aid in understanding the local geography.

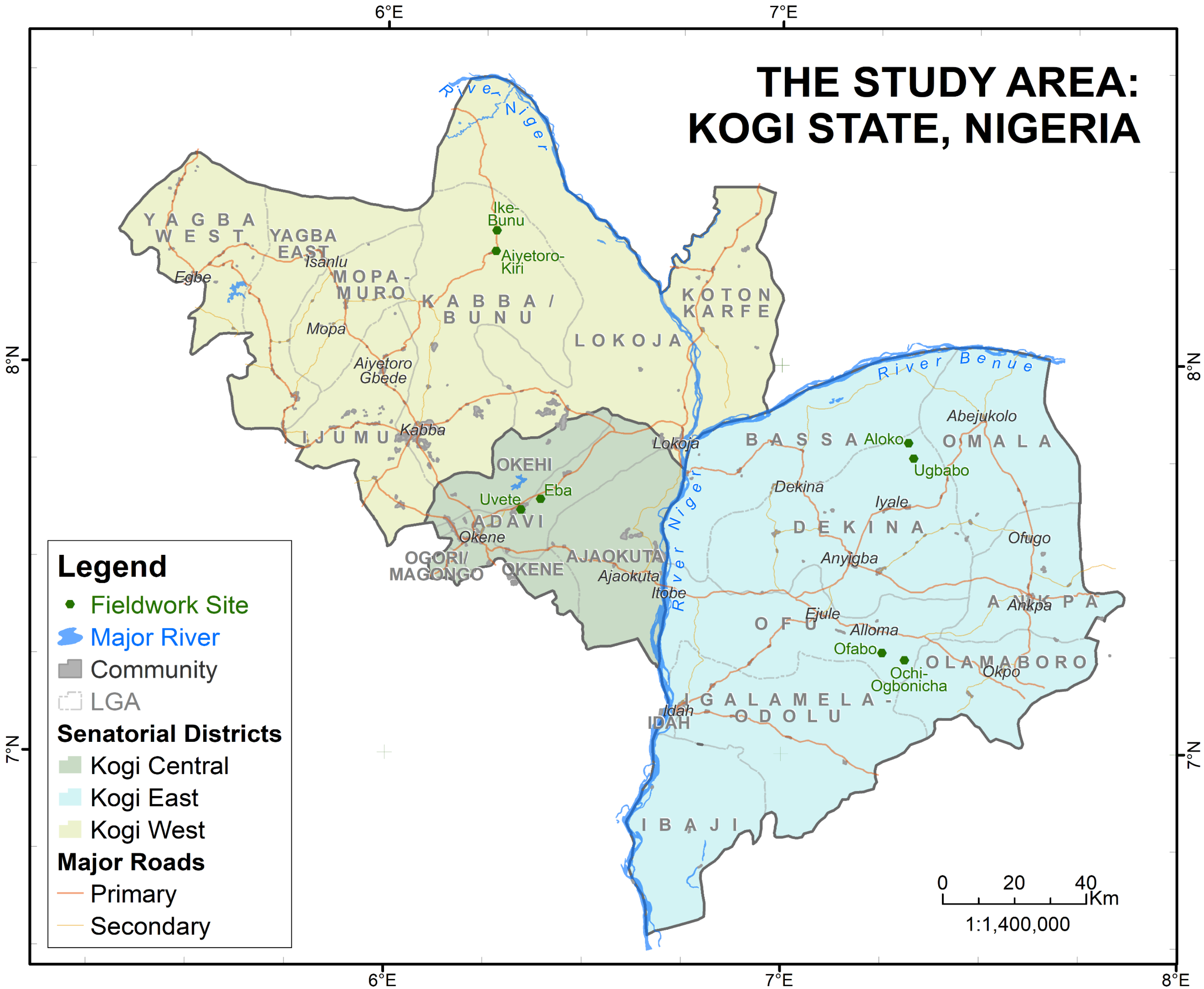


Figure 6-1 Detailed study area map showing some major communities, roads and the fieldwork sites.

6.2 Methods of Data Analyses for Spatial Accessibility

This section discusses the specific steps involved in computing small-area need and per capita supply of baseline healthcare services (i.e. service availability) in Kogi State. This leads to discussions of the transportation network model and the computation of small-area Spatial Accessibility Indices (SPAIs) that result from the interaction of the foregoing variables. Thereafter, the results of the foregoing operations are presented and discussed in section 6.3.

6.2.1 Estimating Healthcare Need: Potential Demand

In this research project, the seven (7) baseline healthcare services identified for the study area by Nigeria's OSSAP-SDGs in partner with the Sustainable Engineering Lab at Columbia University are operationally regarded as PHC services. These are outlined in Table 6-1. This approach enables this study to be consistent with both the health-related SDG and relevant policy agenda of the study area. In this regard, most of the small-area needs for specific PHC services are derived from relevant WorldPop's gridded demographic data (WorldPop Project, 2016; Tatem, 2017) by zonal statistics (particularly, the sum of counts per small-area zone). A bespoke data aggregation geoprocessing tool developed in ArcGIS for this study is used to compute relevant population counts (or ratios) per zone, see Figure 4-3. Family planning services are synonymous with sexual health services; therefore, the number of sexually active people of age 15 – 49 years old is used as the proxy of need for family planning services in the study area. This is derived from the SMM operation of Chapter 5. Although the number/percentage of 'sexually active' persons is not one of the Multiple Indicator Cluster Survey (MICS) indicators (i.e. MICS 5), it is one of the pre-requisite intermediate variables for computing indicators 9.6, 9.12, 9.13, 9.14 and 9.15.

Other MICS 5 variables derived from the SMM of Chapter 5 that could serve as proxies of need for various types of sexual health services include: number or percentage of (young) people who have ever had sex (Indicator 9.9, for young people sub-group); number or percentage of (young) persons who had sex in the last 12 months; mean number of sexual partners in a lifetime; and sex before age 15 among young persons (Indicator 9.10). Another metric that could serve as a proxy of need for family planning services is the proportion of females of reproductive age who use modern contraceptive methods, which is available from the WorldPop demographic grid. However, in addition to being limited to only females, it provides data on health service utilization, which has been shown in Section 2.3.1 to be a poor proxy of healthcare need. Furthermore, it does not cover the gamut of sexual health services; therefore, it is a gross underestimation of the need for family planning service. The adopted demographic measures of healthcare need in this chapter, which are also similar to the denominators of relevant MICS indicators of UNICEF, are outlined in Table 6-1. Statistical methods like factor analyses and Multi-Criteria Appraisal (MCA) can also be used to create multidimensional/composite measures of healthcare needs and socioeconomic deprivation (Cromley and McLafferty, 2012), but these require rich datasets which are not readily available for small-areas of the study area and are outside the scope of the current study.

Table 6-1 Need and supply variables used for computing indices of small-area spatial accessibility to select healthcare services in the study area

Healthcare Service	Measure of Need (per pseudo-ward)	Measure of Supply (per Healthcare Facility): Cadre-Weighted Personnel Index (CWPI)	Approximate Worst-Case Proximity (minutes)	Base Size of Dynamic Catchment Areas (i.e. IDSO)
Maternal Health Services (MHS)	Number of Pregnant Women	CWPI of Facilities with MHS	90	371
Child Health Services (CHS)	People aged 0 – 4 years	CWPI of Facilities with CHS	90	324
Antenatal Care (ANC)	Number of Pregnant Women	CWPI of Facilities with ANC	95	391
Family Planning	Sexually active people (of Age 15 – 49 years)	CWPI of Facilities with Family Planning	90	279
Malaria Treatment (with Artemisinin-based Combination Therapy [ACT])	Total Population	CWPI of Facilities with Malaria Treatment	90	371
Skilled Birth Attendant (SBA)	Number of Pregnant Women	CWPI of Facilities with SBA	100	208
Caesarean Section (CS)	Number of Pregnant Women	CWPI of Facilities with CS	130	100
Functional Health Facilities	Total Population	CWPI of all Facilities	80	412

6.2.2 Modelling Travel-related Disincentive on a Transportation Network

The estimated average speed by which various transportation mediums travel on the different road types in the study area is shown in Table 6-2, similar to Manjia *et al.* (2018, p. 158). The comprehensive road network data obtained from the Open Street Map (OSM) also contain information on one-ways (as To, Fro and Both) and bridges (as True or false). Therefore, these attributes (i.e. road type, one-ways and bridges) are factored into the transportation network model as travel attributes, with relevant evaluators (such as travel speed) scripted with Visual

Basic codes. However, one-way restrictions are not considered when trekking is the travel medium.

Table 6-2 Estimated average speed of various travel mediums in the study area

Code	Road Type	Description	Average Travel Speed (km/hr) by Various Mediums		
			Trekking	**'Okada'**	**Car**
511x	**Major roads**				
5111	motorway	Motorway/freeway	3	50	90
5112	trunk	Important roads, typically divided	3	50	90
5113	primary	Primary roads, typically national.	3	50	90
5114	secondary	Secondary roads, typically regional.	3	50	90
5115	tertiary	Tertiary roads, typically local.	3	50	90
512x	**Minor Roads**				
5121	unclassified	Smaller local roads	3	40	70
5122	residential	Roads in residential areas	3	40	60
5123	Living street	Streets where pedestrians have priority	3	40	40
5124	pedestrian	Pedestrian only streets	3	1	1
513x	**Highway links (slip roads/ramps)**				
5131	Motorway link	Roads that connect from one road to another of the same of lower category.	3	30	40
5132	Trunk link		3	30	40
5133	Primary link		3	30	40
5134	Secondary link		3	30	40
514x	**Very small roads**				
5141	service	Service roads for access to buildings, parking lots, etc.	3	20	20
5142	track	For agricultural use, in forests, etc. Often gravel roads.	3	20	20
5143	Track grade1	Tracks can be assigned a "tracktype" from 1 (asphalt or heavily compacted) to 5 (hardly visible). A detailed description is here: http://wiki.openstreetmap.org/wiki/Tracktype	3	20	20
5144	Track grade2		3	20	20
5145	Track grade3		3	20	20
5146	Track grade4		3	20	20
5147	Track grade5		3	20	20
515x		**Paths unsuitable for cars**			
5151	Bridleway	Paths for horse riding	3	20	1
5152	cycle way	Paths for cycling	3	20	1
5153	Footway	Footpaths	3	20	1
5154	Path	Unspecified paths	3	20	1
5155	Steps	Flights of steps on footpaths	2	1	1
	Unknown				
5199	Unknown	Unknown type of road or path	3	1	1

6.2.3 Computing Small-Area Spatial Accessibility Indices: Optimized Nearest Neighbour – Gaussian 2SFCA (ONN-G2SFCA) Algorithm

The ONN-G2SFCA method of this chapter is implemented using a bespoke geoprocessing model (and tool) of ArcGIS 10.5 software developed by the author, as shown in Figure 6-2 and Figure 6-3 respectively. This model is an adaptation of the G2SFCA script developed by Zhu and Wang (2015), with the main modification being its ability to recursively compute G2SFCA accessibility indices for a series of user-specified distance decay coefficients. Zhu and Wang's (2015) model implements G2SFCA in ArcGIS 10 following steps outlined by Wang (2014b, p. 105). In order to avoid extremely small values, it is the standard practice that a multiplier of 1000 is applied to the raw SPAIs (Wang, 2014b, p. 107). Thus, the SPAIs computed in this thesis indicate service supply per 1000 need population. For each healthcare service, the respective need and supply measures used for computing SPAIs based on the ONN-G2SFCA algorithm are specified in Table 6-1, including the IDSO of various types of PHC services in the study area.

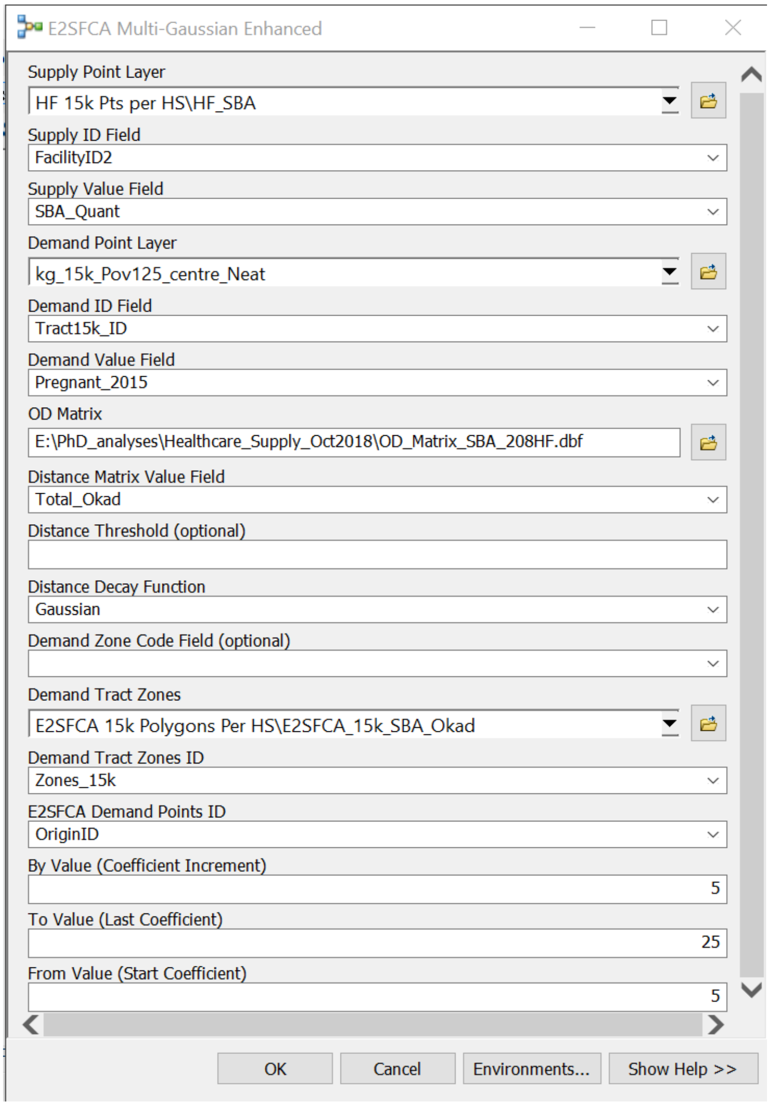


Figure 6-2 The bespoke ArcGIS geoprocessing tool for recursively implementing the ONN-G2SFCA method (Author, 2019)

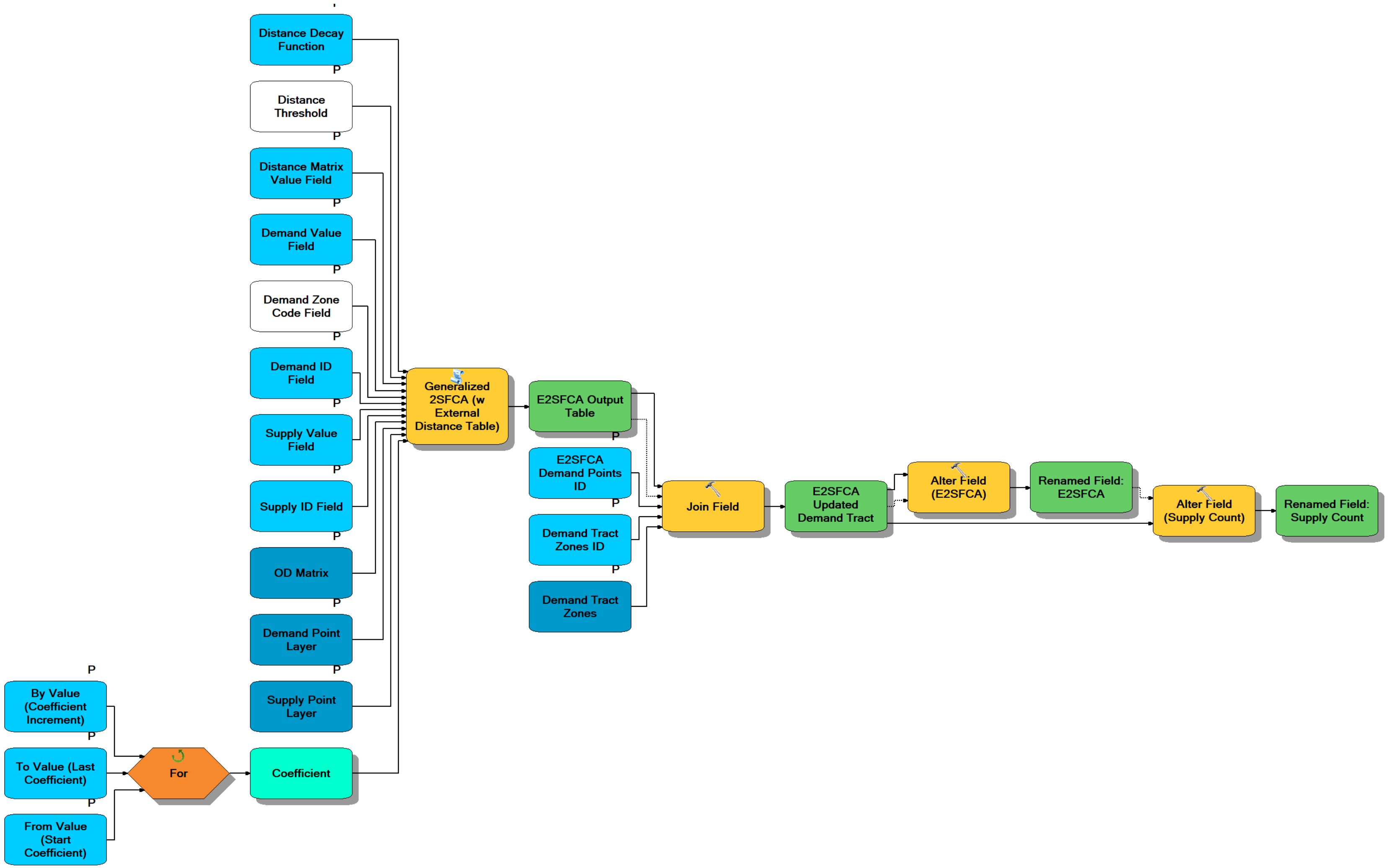


Figure 6-3 The bespoke ArcGIS geoprocessing model for recursively implementing the ONN-G2SFCA method (Author, 2019)

In addition to specifying supply and demand quantities, the ONN-G2SFCA modelling tool requires the specification of the travel impedance (i.e. time/distance) between the respective demand and supply points in the study area. This is provided in the form of an Origin-Destination (O-D) matrix derived from the transportation network model summarized in Section 3.3.3.3. Travel time by *'okada'* is the distance parameter utilized. Notice from Figure 6-2 that no distance threshold is specified because this study employs a variable/dynamic catchment area that is ingrained in the O-D matrix[61].

Raw values derived from the G2SFCA algorithm (otherwise known as SPAI) are essentially supply-to-need ratios, each of which is weighted by travel time (or distance) according to the distance-decay function employed (in this case, the Gaussian function (Wang, 2014b, p. 99)). In this thesis, SPAIs are sometimes standardized to their Z-score equivalent in order to allow for cross-comparisons amongst SPAIs of different healthcare types, which may be incommensurable because they are based on different need population. This is called a **Spatial Accessibility Z-Score (SPAZ)**, which is similar to the **Spatial Access Ratio (SPAR)** (Wan *et al.*, 2012a; Donohoe *et al.*, 2016). Although SPAR is more invariant to changes in G2SFCA model parameters; as well as allowing relative comparison of various geographic contexts, it is inappropriate for identifying MUA/P or HPSA because it is not directly related to provider-to-population ratio like the SPAI (Wan *et al.*, 2012a, 2012b). Being that Z-Score is a well-established statistical index for data standardization, it offers a better opportunity than SPAR for comparing SPAIs of various health service types which are unlikely to have similar value means and ranges, owing to being based on different need variables (Apparicio *et al.*, 2017, p. 11).

The mathematical formula of the G2SFCA algorithm for computing SPAI can be written as (Wang, 2014b, p. 100):

$$\sum_{j=1}^{n}\left[S_j f(d_{ij}) \Big/ \left(\sum_{k=1}^{m} P_k f(d_{kj}) \right) \right],$$

where:

[61] An equal number of supply points for each demand point is used to create the O-D Matrix from the transportation network model, based on IDSO and travel time by *'okada'*.

n and m are the total number of supply and demand locations, respectively;

i and k are demand locations for Step 2 and Step 1 respectively;

j is supply location;

d_{kj} is the distance between k and j, and d_{ij} is the distance between i and j;

S_j is the supply capacity at location j;

P_k is the demand population at location k;

f(d) = f(x) is the specified Gaussian distance-decay weight (or impedance) between demand and supply points in a study area. The mathematical formula of f(x) is (Wang, 2014b, p. 32; Thomopoulos, 2017, p. 70; Ross, 2019, p. 35):

$$f(x) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{-(x-\mu)^2/2\sigma^2},$$

Where:

x (or d) is the travel distance/time between demand and supply points, such that $0 \leq x < \infty$;

μ is the mean travel time/distance in a catchment (x_n);

σ is the specified coefficient of the function for a given study area. This is synonymous with the Standard Deviation (SD) (or scale) of μ.

With the foregoing generalized Gaussian distance-decay function, for hypothetical mean catchment travel times of 15 – 75 minutes (with step-wise increments of 15 minutes), the resulting distance-decay weights/coefficients are illustrated in Figure 6-4B[62]. Although this study is based on a Gaussian distance-decay coefficient (i.e. β or SD) of 15 minutes (i.e. Figure 6-4B), the effects of increasing or reducing β (by 5 minutes) on the resulting distance-decay weights is illustrated in Figure 6-4. The distance-decay values in Figure 6-4 (A, B and C) also correspond with the SPAI derived from using 10, 15 and 20 minutes respectively as distance-decay coefficients (i.e. β) for the factor analysis explained in Appendix A.2.

[62] These weights were computed and plotted in MS Excel using the function: Inverse Gaussian Weight = 1 – (NORM.DIST(travel times series, mean, SD, Cumulative: True)).

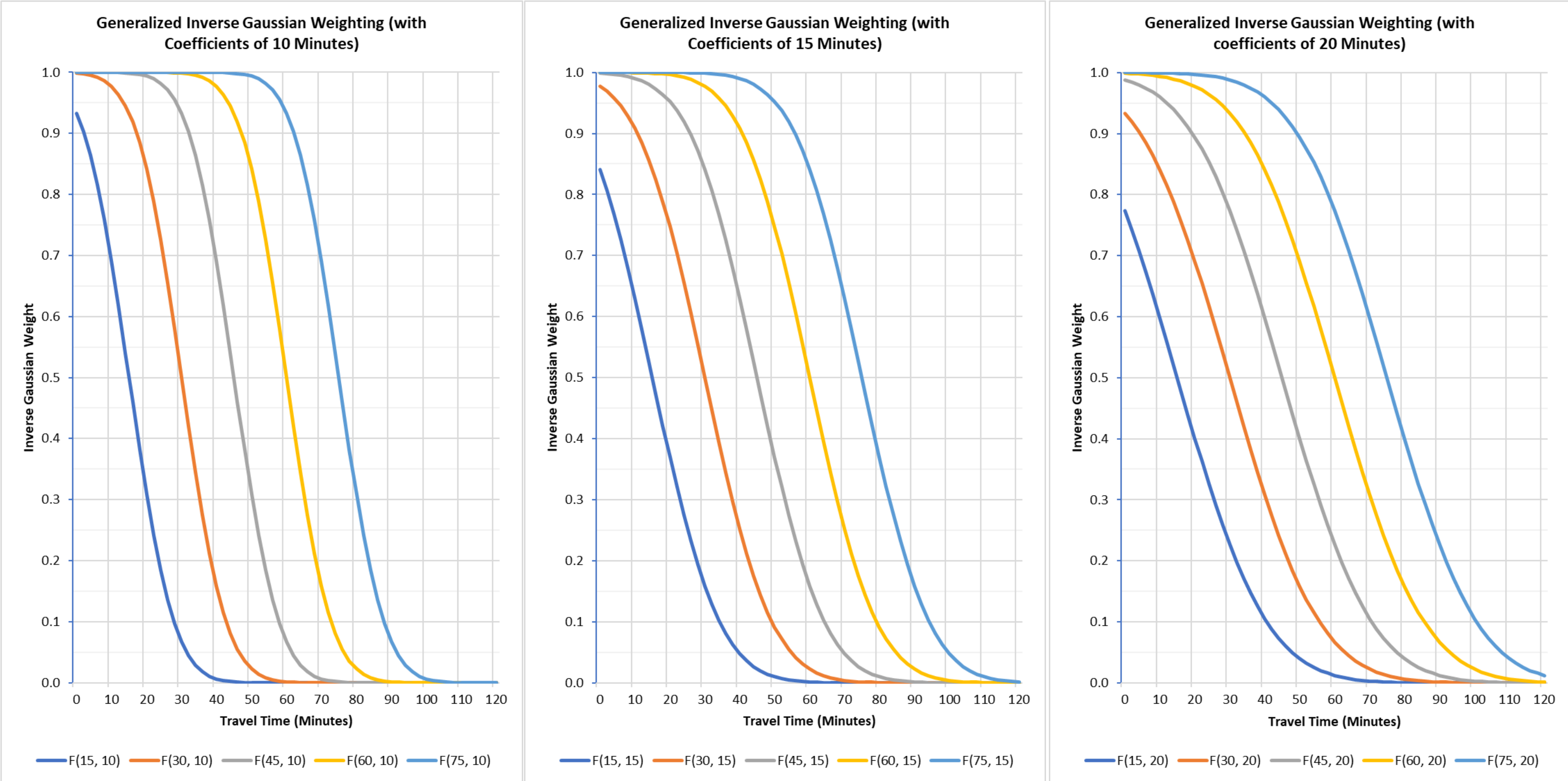


Figure 6-4 Generalized Gaussian distance-decay weighting values for hypothetic variable catchment areas with mean travel times of 15 to 75 minutes, with step-wise increments of 15 minutes and coefficients of: (A) 10 minutes, (B) 15 minutes and (C) 20 minues. Here, y = F(t, x); where y = gaussian distance-decay weight; t = travel time between demand and supply points; and x = distance-decay coefficient, which is the expected SD of travel time (or distance) in a catchment area.

In the current study which uses a variable catchment area, this formulation of gaussian continuous distance-decay weighting has key advantages over other variants of Gaussian distance-decay function (Bauer and Groneberg, 2016, p. 7). For instance, the catchment of each demand location has some bespoke distance-decay function parameters, particularly the mean (μ) travel distance/time in a catchment, which is determined by *n* nearest supply points (where *n* is the so-called IDSO). μ is therefore an estimate of the average travel time/distance that potential healthcare users would be willing to cover given the spatial organization of *n* proximal healthcare facilities in a catchment. The effect is that this mean value is the distance at which the gaussian weight is 0.5 in a catchment. With greater values of μ come increased willingness to travel longer distances in each catchment, and vice versa. The coefficient of the Gaussian function (i.e. the SD or β) not only alters the slope of the distance-decay weighting but also serves as an estimate of the expected degree of variation in distance-decay weights relative to a catchment's mean travel distance/time. Therefore, both μ and β are also associated with the notion of '**threshold of travel indifference**' (or the notion of local travel) (Manaugh and El-Geneidy, 2012, p. 20; Vale and Pereira, 2016, p. 747). This explains the proximal service area in which travel-related disutility is negligible.

A third step (of the G2SFCA), known as the 3SFCA method, is aimed at overcoming need-related aggregation errors in the analysis of spatial accessibility (Wan *et al.*, 2012b; Bell *et al.*, 2013). It entails using the 2SFCA method (or any of its improved variants) to calculate a spatial accessibility index at a relatively finer zoning system than needed, after which a weighted sum of SPAIs is computed for each contextually-relevant coarse zone in a study area. In contexts like the current study area which lack any such fine zones, synthetic small-area analytical zoning systems can be used for the original computation of SPAIs, after which they are aggregated to the available coarse zones. Indeed, this is the approach implemented in the current study for computing SPAIs for the contextually-meaningful LGAs and Senatorial Districts, unlike the bland synthetic small-area analytical zoning system developed in Chapter 4. However, the use of an optimized small-area analytical zoning system is adept at mitigating context-specific aggregation problems of a study, to the extent that the analytical zoning system is more optimized than readily available small-area zoning systems in developed countries. In the analysis of spatial accessibility, unoptimized small-area zones (like regular tessellations) will embody and propagate aggregation errors to higher geographies, though to a much-reduced extent because of their enhanced spatial fidelity.

6.3 Presentation and Discussion of Results on Spatial Accessibility

Spatial accessibility is typically determined by the interaction between three variables, namely: need, supply and transportation (Guagliardo, 2004; Tanser *et al.*, 2010; Henry and McDonald, 2013). Therefore, this section starts by mapping and discussing small-area need for baseline healthcare services, after which their per capita zonal supply (i.e. availability) is considered. Following this, the spatial accessibility index (SPAI) of each PHC service is discussed at multiple spatial scales. As explained in Section 4.3.1, all choropleth maps in this thesis are classified by natural breaks unless stated otherwise.

6.3.1 Estimates of Small-Area Need for Primary Healthcare: Potential Demand

Figure 6-5A shows that small-area need for family planning services ranges from 3,231 – 9,158 people of age 15 – 49 years, with the majority of localities (183, 53.66% of analytical wards) having 3,844 – 5,309 sexually active people. The northern zones of Kogi East tend to have more sexually active people than the southern flank. Except for Lokoja town, localities in Kogi West and Kogi Central with a preponderance of sexually active people tend to be in the southern and south-western areas. Need for CHS per small-area ranges from 1,195 to 6,212 people; with modal need being 2,104 – 2,529, which accounts for 31.97% (109) of analytical wards in the study area, as shown in Figure 6-5B. Small-area need for pregnancy-related services is shown in Figure 6-5D, in which the number of pregnant women ranges from 165 – 1,323 and the modal category is analytical zones with a 409 – 506 pregnancy count. 38.42% (131) of small-areas in the study area belong in this category. In Figure 6-5C is the total small-area population of the study area, which constitutes the need for Malaria Treatment (with ACT) as well as the general need for hospitals and services (in contrast to service-specific healthcare need). The population of analytical wards is between 9,998 and 25,908, with the modal category being 11,852 – 14,215, which constitutes 36.66% (125) of analytical wards in the study area. Overall, analytical wards with high healthcare need tend to be major towns, which are sites of population concentration.

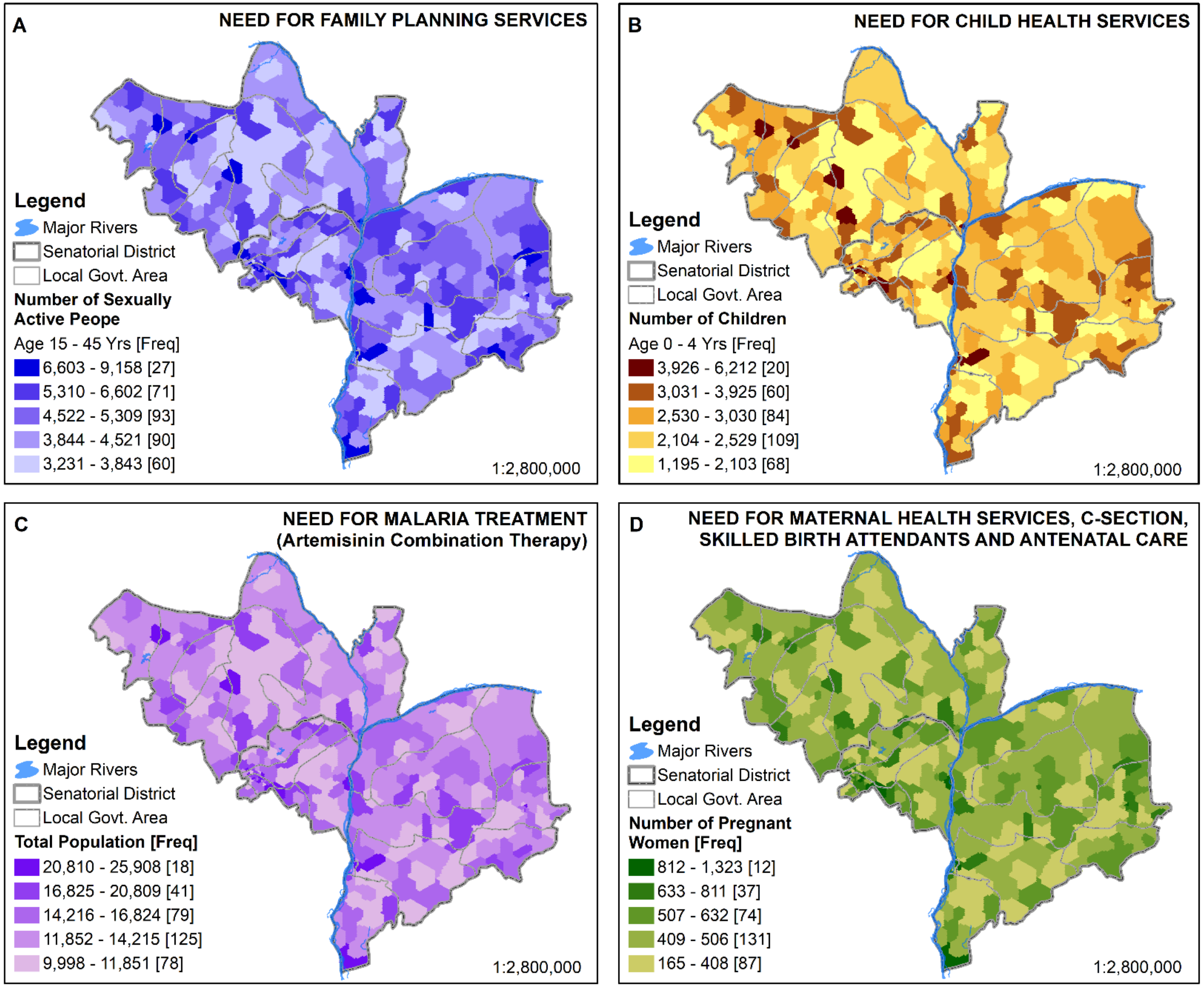


Figure 6-5 Small-Area estimates of need for baseline healthcare services in Kogi State, Nigeria

Being spatially optimized small-area analytical zones as discussed in Section 3.3.1 and Chapter 4, the size of small-areas is customized to ensure that no zone is less than 10,000 people (i.e. standardized and balanced population). This also implies that the majority of high-density population zones are very small (being about 1 km^2, based on the size of the hexabins used as Building Block Area (BBAs) for the automated zone design). Therefore, they are unlikely to be apparent in these maps unless efforts are made at zooming into these places with the use of insets.

A graphical summary of small-area variations in the population of relevant need variables is presented in Figure 6-6, using box plots. Each box (with whiskers and dots) shows the interquartile range, median and outliers (or extreme values) of small-area need population within each LGA. The least populous (and smallest) LGA in Kogi East (Idah) has the largest interquartile range of small-area population (for all need variables) in the same senatorial district. Whereas in Kogi Central, the most populous LGA (Okene) has the largest interquartile range in both its senatorial district and the entire study area. Slightly different patterns of interquartile range are observable for each of the other need variables. Overall, observable small-area population variations are different from variations in the need population for specific PHC services. This implies that spatial accessibility indices will vary based on relevant need variables, and general small-area population is not a good proxy of need for specific services (like child health) (Ricketts *et al.*, 2007; McGrail and Humphreys, 2015; Saxon and Snow, 2020). It is therefore important to use precise (proxies of) need variables for the particular healthcare service being studied in order to obtain realistic indices of spatial accessibility in any context, as practiced in the current thesis. The next section discusses the per capita supply of baseline healthcare services in the study area (i.e. availability), as a prelude to the actual analysis of spatial accessibility in a subsequent section.

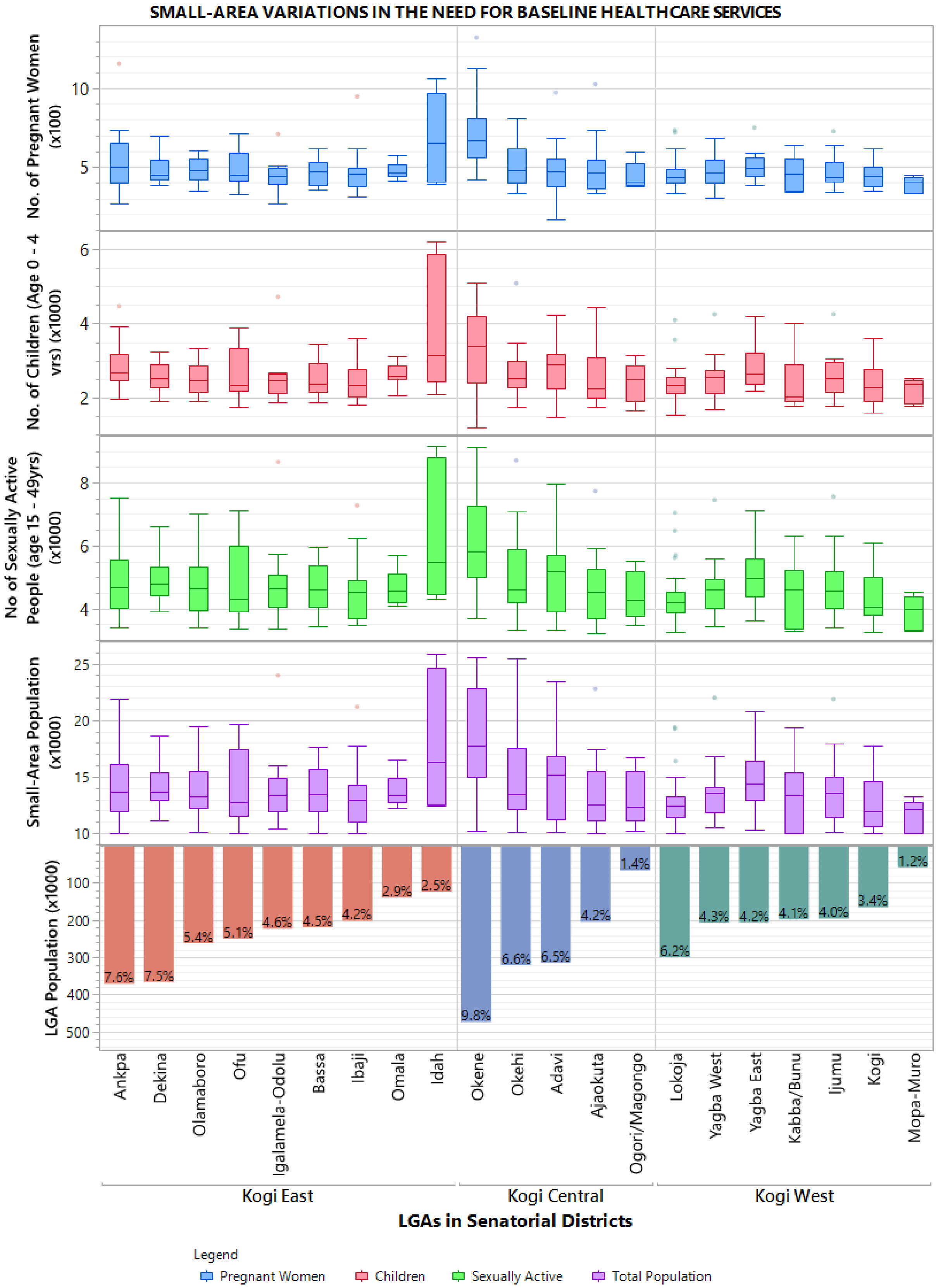


Figure 6-6 Characteristics of small-area variations in the population of relevant need variables for healthcare services in the study area

6.3.2 Small-Area Per Capita Supply of Primary Healthcare: Availability

Service availability is typically based on Provider-to-Population Ratio (PPR), which is a metric of hospital or service per capita supply. However, this section features a precise variant of PPR with quantity of service-specific providers and estimates of need premised on the demographic profile of various localities. Consequently, a more precise name for the availability metric computed in this section is Supply-to-Need Ratio (SNR). Section 6.3.1 shows that within LGAs, there are staggering small-area variations in healthcare needs (see Figure 6-6). This forms the basis for computing PHC availability (i.e. per capita supply) depicted in Figure 6-7 (A to D) and Figure 6-8 (A, C and E). Furthermore, (service-specific) hospital availability is subtracted from cadre-weighted personnel availability to reveal probable understaffed synthetic wards, as shown in Figure 6-7 (E to F) and Figure 6-8 (B, D and F).

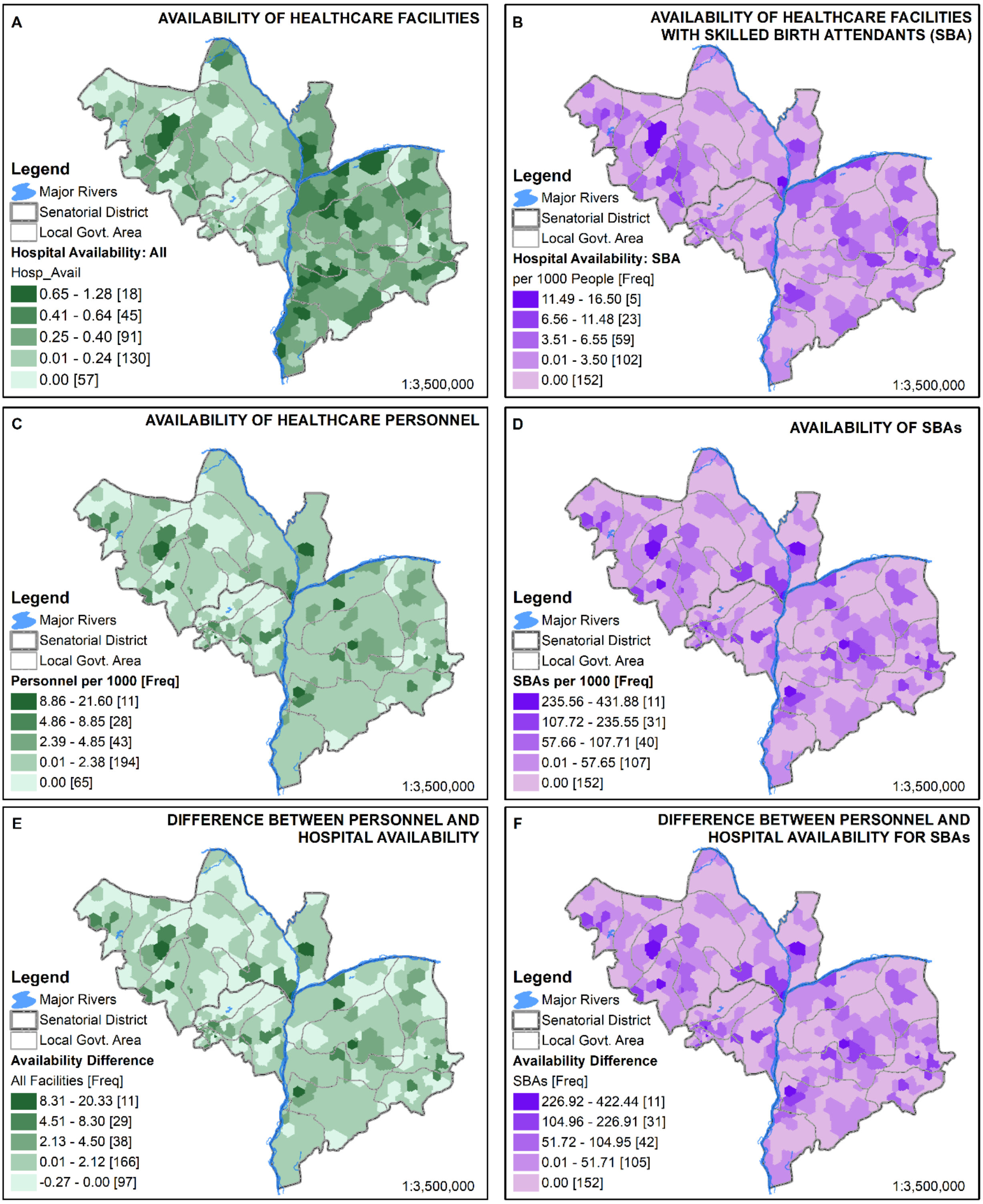


Figure 6-7 Small-Area availability of hospitals and Skilled Birth Attendants (SBAs) in the study area, showing localities that lack hospitals or whose hospitals are very understaffed (see E and F).

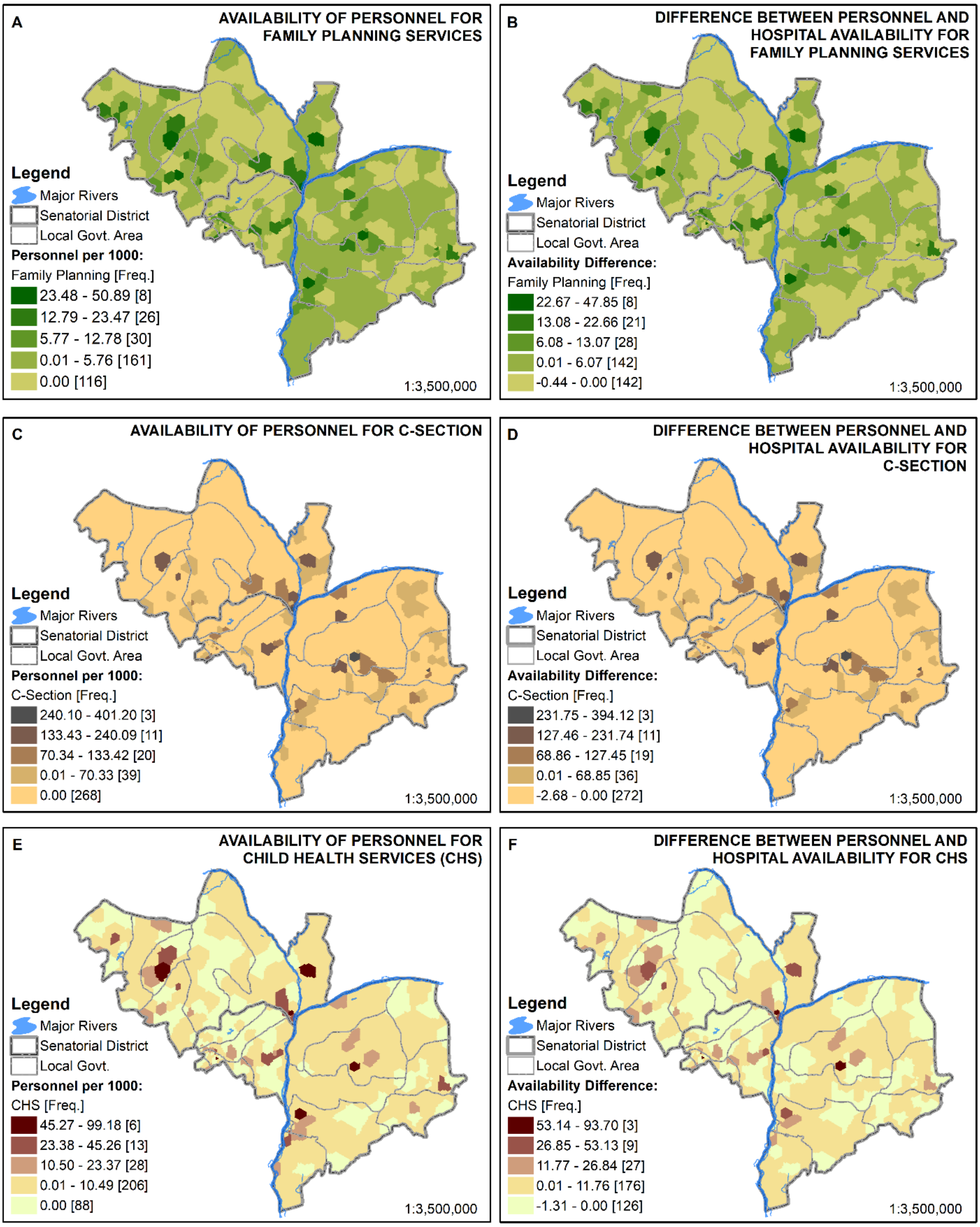


Figure 6-8 Small-Area Availability of Family Planning Services, C-Section and Child Health Services (CHS) in the study area, showing localities that lack hospitals and/or whose hospitals are very understaffed (see B, D and F).

In terms of hospital availability, the best served analytical ward(s) have 13 hospitals per 10,000 people, while 57 wards (16.72%) have no hospital at all, as shown in Figure 6-7A. The modal availability of hospitals is 0.1 – 2.4 per 10,000 people, in which 130 wards belong (38.12%). In this regard, Kogi East is seen to exhibit a preponderance of hospital availability, while there are large areas in both Kogi Central and Kogi West that lack a hospital. However, when service-specific availability of hospitals is considered, a different pattern is observed, as shown in Figure 6-7B. Concerning hospitals with Skilled Birth Attendants (SBAs), the best served analytical ward has 165 hospitals with SBA per 10,000 pregnancies, while 152 wards (44.58%) have got no SBA-providing hospital in the study area. Also, the modal availability of SBA hospitals is 0.1 – 35 hospitals per 10,000 pregnancy, of which 102 wards belong (29.91%). This implies that the availability of hospitals is very different from service availability (even if service capacity is not considered) and exhibits very different small-area patterns, as can be seen by comparing Figure 6-7A to Figure 6-7B. For instance, the preponderance of hospitals' presence in Kogi East, which is shown in Figure 6-7A, vanishes when SBA availability is considered in Figure 6-7B. Indeed, Figure 6-7B shows a near-even spread of areas that lack SBA hospitals across the three senatorial districts in the study area. Furthermore, while Figure 6-7A shows that 16.72% of analytical wards lack any hospital, this increases to 44.58% of wards that lack an SBA presence, a staggering 27.86% increase in lack. This also suggests that most of these wards are in Kogi East, owing to the obvious attenuation effect that the consideration of SBA has caused for that region. It is therefore pertinent that among other things, analysis of spatial accessibility in this study is sensitive to service availability as further discussions demonstrate.

Having revealed the potential effect of considering specific services in the analysis of spatial availability (regardless of service capacity), cadre-weighted staff availability for both hospitals and the specific services therein are hereby discussed. From Figure 6-7C, it can be seen that the best served analytical ward in terms of availability of healthcare personnel has 216 personnel per 10,000 people, with the modal availability being 0.1 – 24 personnel per 10,000 people for 194 wards (56.89%). In 65 wards, there are no healthcare personnel, in contrast to the 57 wards which lack a hospital, as shown in Figure 6-7A. This indicates that eight (8) of the analytical wards with hospitals lack medical personnel, implying that all hospitals in those wards are non-functional. The presence of non-functional healthcare facilities was also observed during the qualitative fieldwork in the study area, as discussed in further in Section 7.3, but it was not apparent that there could be entire wards which lack a hospital or have all of their available hospitals being non-functional for lack of staff members[63]. The preponderance of hospital availability in Kogi East shown in Figure 6-7A disappears with the computation of per capita cadre-weighted personnel supply. A slightly different small-area pattern in healthcare availability is also revealed when the staff strength of facilities with SBAs is considered in Figure 6-7D. As with Figure 6-7B, 152 facilities have no SBAs, while wards with SBAs have a modal availability of 0.1 – 577 per 10,000 pregnancies as possessed by 107 wards (31.38%). Unlike Figure 6-7A and C, all hospitals offering SBA services have at least one SBA staff; hence there is no increase in the number of wards lacking SBAs when Figure 6-7B is compared to Figure 6-7D. The best-supplied ward has 4,319 cadre-weighted SBAs per 10,000 pregnancy.

The difference that results from considering cadre-weighted availability in contrast to the mere presence of a hospital is further explored in the difference maps of Figure 6-7E and F(for SBAs). In these maps, wards with one member of staff per hospital (particularly CHEW) will have equal availability metrics for both health facility and cadre-weighted availability, which will produce a difference of zero. A negative difference value shows that there are more hospitals than staff members in a zone, while with increasing difference value comes better staffing of hospitals in various wards. Figure 6-7E shows that 97 analytical wards either lack hospitals or have extremely understaffed hospitals of about one (1) member of staff per hospital. Indeed, as 65 wards lack any healthcare personnel (as shown in Figure 6-7C), it suggests that hospitals in 32 more wards are extremely understaffed in any of the following ways: (1) these wards have about one staff member per hospital, as such the computed availability difference is zero; or (2) these wards have more hospitals than cadre-weighted staff availability, in which case the computed availability difference is a negative value. Based on the foregoing analysis, Figure 6-8 are maps that show small-area spatial patterns of both cadre-weighted staff availability for specific healthcare services and their associated availability differences. Of the 341 analytical wards in the study area, 116 (34.02 %), 268 (78.6 %) and 88 (25.81 %) wards lack personnel for family planning, C-Section and Child Health Services respectively. Among other things, this also shows that while C-Section and SBA have the worst availability in the study area, they are also the most unequally distributed services, as suggested by the very high availability metrics of the best-served wards. For instance, in

[63] The current study is based on optimized analytical wards; therefore, this may not be the case for actual political wards, but is worth exploring in subsequent studies.

terms of cadre-weighted staff availability, the best-served ward has 4319, 509, 4012 and 992 personnel per 10,000 need for SBA, family planning, C-Section and CHS respectively. See Figure 6-7D, Figure 6-8A, C and E. Being that C-Section (as well as SBA) tend to be relatively more expensive services in the study area, their staggering disparity amidst dire short supply is likely a consequence of the tendency of these services to agglomerate in highly populated affluent urban centres which have the threshold requirement to sustain their supply.

6.3.2.1 Availability of Primary Healthcare Services Aggregated at Coarse Spatial Scales: LGAs and Senatorial Districts

Availability at higher geographies (in particular, LGAs and Senatorial Districts) is computed by aggregating small-area availability using weighted means. The weights applied are the relevant need variable for a given availability metric. This effectively accounts for the variations in the small-area need population, such that the derived aggregate availability is sensitive to the proportion of needy population that benefits from various small-area supply. This is more precise than directly computing service availability at mesoscale geographies using their per capita supply, which is usually insensitive to their inherent variations in service supply at the microscale. This is the rationale for the third step of the 3SFCA (Bell *et al.* 2013, p. 9), which is also implemented in aggregating the SPAIs computed in this chapter, as discussed in Section 6.3.3.2.

Overall, Figure 6-9 and Figure 6-10 reiterates that the per capita supply of healthcare facilities is markedly different from the per capita supply of healthcare personnel (i.e. service capacity). Even though Kogi East tends to have more healthcare facilities than the other senatorial districts, the per capita supply of personnel is not as much as would have been expected considering the relative abundance of facilities in the same district. Conversely, although Kogi Central has a much lower availability of healthcare facilities, their per capita personnel count for both general PHC services and C-S services are much better than expected. With these personnel and service availability advantages, coupled with their much higher population density (discussed in Section 4.3), it would not be very surprising if in Section 6.3, Kogi Central is shown to exhibit much better spatial accessibility than other senatorial districts in the study area.

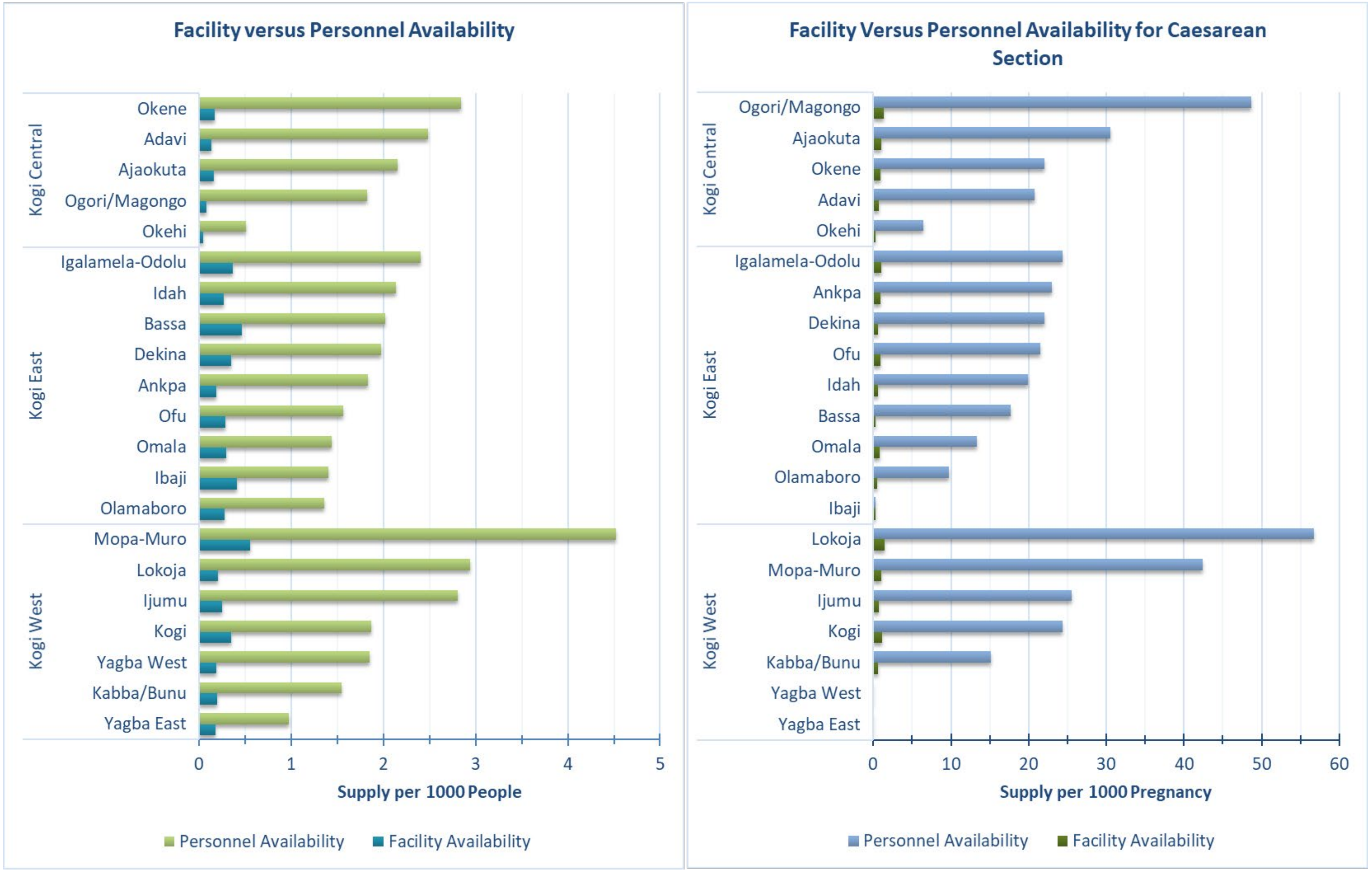
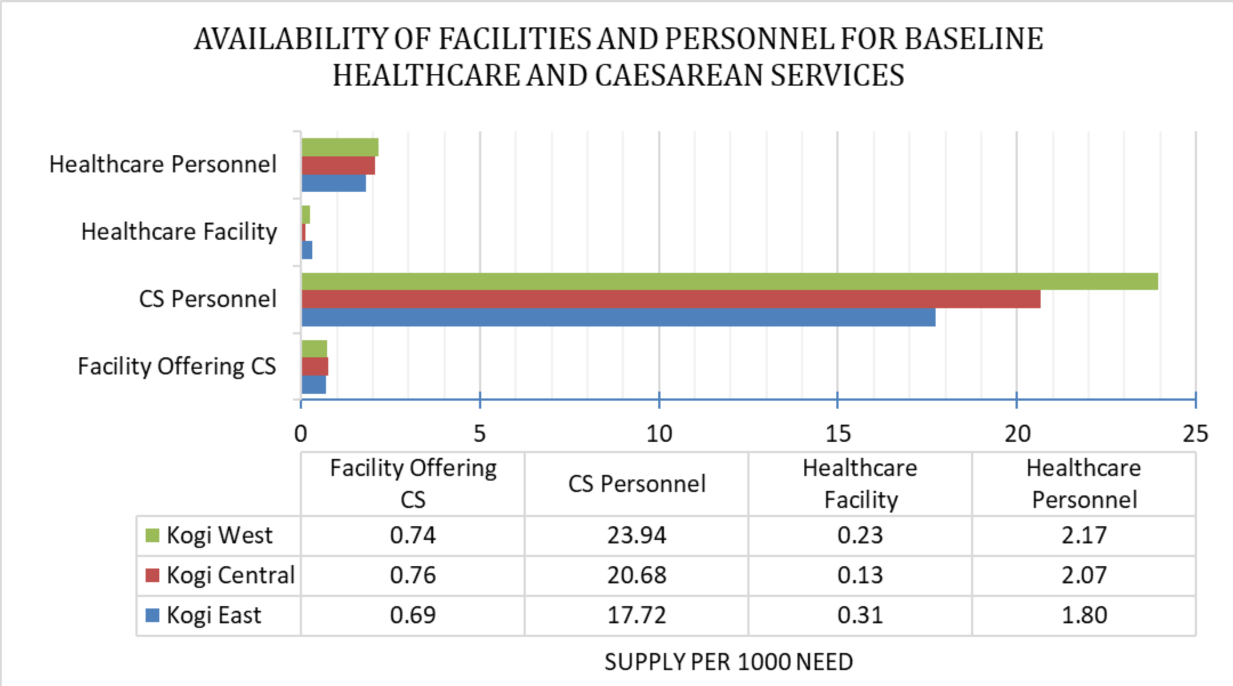


Figure 6-9 Differences is personnel availability and service availability per LGA. The graph on the right shows availability differences that are observable when only CS services are considered per LGA.



	Facility Offering CS	CS Personnel	Healthcare Facility	Healthcare Personnel
Kogi West	0.74	23.94	0.23	2.17
Kogi Central	0.76	20.68	0.13	2.07
Kogi East	0.69	17.72	0.31	1.80

Figure 6-10 Differences is personnel availability and service availability per Senatorial district, showing CS-specific service availability.

In sum, these observed internal variations in both need and availability of healthcare services are often masked if access-related analyses are conducted at LGA scales or more coarse spatial scales like the state and country, which are the most popular levels of disaggregation for data analysis by many (inter)national organizations like the DHS and UNICEF. The availability of a hospital is not synonymous with the availability of services, as there are many hospitals that lack certain services. Even when a service is provided by a hospital, there are great differences in the service-delivery capacity of various hospitals, and there are small-area variations in these differences, as shown in Figure 6-8 (and Figure 6-9). Indeed, there are many hospitals with records of service delivery which lack the requisite personnel. Thus, it is necessary for analysis of access to always factor precise quantity of service-specific need as well as the quantity of particular services supplied, especially in developing contexts like the study area (Unal *et al.*, 2007; Tanser *et al.*, 2010; Plachkinova *et al.*, 2018, p. 293). This is discussed further in the next section wherein small-area spatial accessibility of PHC services is presented and discussed at multiple spatial scales.

6.3.3 Service-Specific Spatial Accessibility Indices (SPAI) at Multiple Spatial Scales

The small-area SPAI and SPAZ metrics discussed in this section were computed with the bespoke ONN-G2SFCA algorithm developed in sections 3.3.3.5 and 6.2.3. The findings thereof are hereby explicated at multiple spatial scales, starting with the synthetic analytical wards.

6.3.3.1 Spatial Accessibility Scores of Small-Area Zones: Synthetic Wards

Maps and tables of the spatial accessibility indices are presented in this section for each baseline healthcare service in the study area. Based on mean spatial accessibility indices, the ten most accessible and ten least accessible small-area zones are highlighted in Table 6-3 and Table 6-4 for the SPAI and the associated SPAZ respectively. Following the factor analysis results presented in Appendix A.2, this study focuses on accessibility indices derived using the 15 minutes distance-decay coefficient. Raw SPAI scores are mapped in Figure 6-14 and Figure 6-15 (A and B), while relevant Z-scores (SPAZ) are mapped in Figure 6-15 (C and D). Whereas SPAZ is useful for understanding the extent of small-area accessibility relative to the mean accessibility in a study area, the actual SPAI is more meaningful in that it serves as a Floating Catchment Area (FCA) variant of the popular PPR discussed in Section 6.3.2 above. By focusing only on a locality's accessibility relative to the mean of a study area, SPAZ is problematic in that it is sensitive to the geographic context of a study area and tends to show significant variations in spatial accessibility to the extent that they deviate from a study area's mean. In this way, a very large and/or heterogeneous study area which contains pockets of both very good and awfully poor accessibility will show notable variations in SPAZ value, and thus enable the identification of extremely (dis)advantaged localities. However, a small or relatively homogeneous study area may not show much variations in SPAZ, since all the SPAI values will be close to the study area's mean. Hence, despite some criticisms (Wan *et al.*, 2012a; Donohoe *et al.*, 2016), SPAI is more meaningful than SPAZ for planning and policymaking but can be supported by SPAZ for some types of comparative studies or mapping, being a standardized measure. For instance, SPAZ is useful for comparing accessibility across various services types in a study area, which may possess very different value ranges, especially when different need populations are utilized, as shown in Figure 6-15 (C and D). This greatly aids cross-comparisons between and within maps by helping to show the extent to which accessibility indices deviate from their respective means. This is further illustrated with the use of Cumulative Density Plots in Figure 6-16. CDPs, also known as ogives, are useful in showing how percentage coverage reduces as spatial accessibility metrics increase, and vice versa (Cromley and Ye, 2006).

Table 6-3 The best ten and worst ten synthetic wards in Kogi State, based on their SPAIs of baseline healthcare services.

Ward Code	LGA	Senatorial District	SPAI for:									Rank
			HC Staff	C-Sect	ANC	CHS	Family Planning	Malaria (ACT)	MHS	SBA	Mean SPAI of Services	
FN-99	Lokoja	Kogi West	9.42	180.53	259.40	36.92	23.29	8.70	256.00	251.36	145.17	1st
FJ-97	Lokoja	Kogi West	9.05	172.93	249.30	35.73	22.44	8.37	246.26	241.66	139.53	2nd
FN-102	Lokoja	Kogi West	8.99	174.71	248.04	35.43	22.37	8.31	244.06	240.15	139.01	3rd
FL-112	Ajaokuta	Kogi Central	6.36	125.76	175.68	25.01	15.76	5.87	171.47	169.13	98.39	4th
FF-98	Lokoja	Kogi West	5.85	111.19	161.04	21.65	14.51	5.43	160.15	156.89	90.12	5th
CB-81	Ijumu	Kogi West	4.67	88.95	122.20	20.47	12.20	4.50	120.60	129.64	71.23	6th
BV-79	Ijumu	Kogi West	4.51	74.54	116.95	19.10	11.74	4.33	114.73	121.23	66.09	7th
BN-97	Ijumu	Kogi West	4.32	20.31	108.99	12.49	10.17	3.31	117.46	114.32	55.29	8th
BP-75	Mopa-Muro	Kogi West	4.31	46.03	113.72	18.08	10.86	4.11	109.78	104.30	58.13	9th
BV-95	Ijumu	Kogi West	4.11	21.97	106.47	9.35	10.10	3.44	106.71	110.08	52.59	10th
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
DR-104	Okehi	Kogi Central	0.15	1.04	3.49	0.53	0.33	0.14	3.48	3.76	1.82	332nd
EB-102	Okehi	Kogi Central	0.15	1.04	3.49	0.53	0.33	0.14	3.48	3.76	1.82	333rd
EN-73	Lokoja	Kogi West	0.15	0.91	4.25	0.24	0.13	0.06	4.26	4.14	2.00	334th
V-74	Yagba West	Kogi West	0.12	0.01	3.42	0.65	0.26	0.10	3.15	2.99	1.51	335th
CX-17	Lokoja	Kogi West	0.11	0.00	2.51	0.46	0.22	0.09	2.10	0.62	0.86	336th
EL-153	Ajaokuta	Kogi Central	0.10	0.85	2.70	0.32	0.28	0.10	2.59	2.01	1.26	337th
EW-119	Ajaokuta	Kogi Central	0.09	0.31	1.80	0.24	0.17	0.06	1.69	2.14	0.91	338th
GP-203	Igalamela-Odolu	Kogi East	0.04	0.00	0.57	0.11	0.00	0.02	0.57	1.26	0.36	339th
CZ-54	Kabba/Bunu	Kogi West	0.04	0.00	0.22	0.04	0.02	0.04	0.01	0.85	0.17	340th
DD-70	Kabba/Bunu	Kogi West	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	341st

Table 6-4 The top ten and bottom ten synthetic wards in Kogi State, based on the SPAZ of baseline healthcare services.

Ward Code	LGA Name	Senatorial District	Z-Score of SPAI (i.e. SPAZ) for:									Rank
			HC Staff	CS	ANC	CHS	Family Planning	Malaria	MHS	SBA	Mean SPAZ of Services	
FN-99	Lokoja	Kogi West	5.60	6.80	5.85	6.53	5.70	5.60	5.86	5.80	6.02	1st
FJ-97	Lokoja	Kogi West	5.32	6.48	5.56	6.28	5.45	5.33	5.59	5.52	5.75	2nd
FN-102	Lokoja	Kogi West	5.27	6.56	5.53	6.22	5.43	5.29	5.52	5.48	5.72	3rd
FL-112	Ajaokuta	Kogi Central	3.30	4.48	3.50	4.01	3.47	3.35	3.46	3.47	3.68	4th
FF-98	Lokoja	Kogi West	2.92	3.86	3.09	3.30	3.10	2.99	3.14	3.13	3.23	5th
CB-81	Ijumu	Kogi West	2.03	2.91	2.00	3.05	2.41	2.25	2.01	2.36	2.43	6th
BV-79	Ijumu	Kogi West	1.91	2.30	1.86	2.76	2.27	2.11	1.85	2.12	2.18	7th
BP-75	Mopa-Muro	Kogi West	1.76	1.09	1.77	2.55	2.01	1.94	1.71	1.64	1.82	8th
HJ-129	Dekina	Kogi East	1.59	1.99	1.70	1.52	1.35	1.71	1.55	1.59	1.63	9th
FX-72	Kogi	Kogi West	1.47	1.76	1.57	1.89	1.17	1.71	1.66	1.44	1.60	10th
-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-
DH-47	Kabba/Bunu	Kogi West	-1.28	-0.86	-1.32	-1.09	-1.21	-1.28	-1.32	-1.22	-1.19	332nd
EL-153	Ajaokuta	Kogi Central	-1.41	-0.83	-1.34	-1.21	-1.13	-1.26	-1.34	-1.25	-1.19	333rd
DJ-32	Lokoja	Kogi West	-1.30	-0.86	-1.34	-1.10	-1.21	-1.26	-1.36	-1.24	-1.20	334th
DQ-62	Kabba/Bunu	Kogi West	-1.34	-0.86	-1.35	-1.17	-1.18	-1.29	-1.34	-1.20	-1.20	335th
CT-33	Lokoja	Kogi West	-1.31	-0.86	-1.35	-1.13	-1.20	-1.25	-1.38	-1.23	-1.20	336th
CX-17	Lokoja	Kogi West	-1.40	-0.86	-1.35	-1.18	-1.15	-1.26	-1.35	-1.29	-1.21	337th
EW-119	Ajaokuta	Kogi Central	-1.42	-0.85	-1.37	-1.23	-1.16	-1.28	-1.37	-1.25	-1.21	338th
GP-203	Igalamela-Odolu	Kogi East	-1.45	-0.86	-1.40	-1.25	-1.21	-1.32	-1.40	-1.28	-1.25	339th
CZ-54	Kabba/Bunu	Kogi West	-1.45	-0.86	-1.41	-1.27	-1.20	-1.30	-1.41	-1.29	-1.25	340th
DD-70	Kabba/Bunu	Kogi West	-1.48	-0.86	-1.42	-1.28	-1.21	-1.33	-1.41	-1.31	-1.26	341st

Nine (9) of the ten (10) wards most accessible to healthcare personnel are in Kogi West, as shown in Table 6-3, the only exception being 'FL-112' in Kogi Central. It is not surprising that the top three of these wards are in Lokoja town (in Lokoja LGA), which is the administrative capital of the state. Furthermore, four (4) of the top five (5) wards, all of which are also positive outliers[64] (as shown in Table 6-4), are in Lokoja town (in Lokoja LGA of Kogi West), with the only exception being ward 'FL-112' in Ajaokuta LGA (ranked 4th best) which is in Kogi Central. However, synthetic ward 'FL-112', which is the only one in Kogi Central that features amongst these top ten, is adjacent to Lokoja LGA, southwards, as shown in Figure 6-14[65]. Hence, though a ward in Ajaokuta LGA, 'FL-112' is within the metropolis of Lokoja town and therefore benefits from the extreme concentration of healthcare services in a neighbouring LGA, Lokoja. When the mean SPAZ of service-specific accessibility is analyzed (as shown in Table 6-4, mapped in Figure 6-15D), only one ward in Kogi East (i.e. 'HJ-129' in Dekina LGA) features in the top ten category (ranked 9th), but is not a positive outlier. Most others are in Kogi West, similar to the ranked pattern of SPAI scores in Table 6-3.

Being the administrative capital of Kogi State, Lokoja town is both the economic and political nerve-centre of the study area, hence its ability to attract and sustain large public and private hospitals and healthcare personnel (as well as other goods and services). Private hospitals would locate their services in Lokoja town because of its economic appeal. Most political office holders have their official residences in Lokoja; consequently, they are also likely to influence the siting of large public hospitals in this same town, for potential self-benefits, including favourable political optics. Furthermore, being about the most urbanized town in Kogi State, most medical personnel are more interested in residing in Lokoja in order to benefit from the increased quality of life that comes with urban living in developing contexts. Indeed, as will be discussed in Chapter 7, many health personnel in the study area are able to influence their transfers from undesirable rural areas to attractive urban centres like Lokoja.

It is, however, ironical that despite having the most accessible wards (which are also positive outliers in the study area), three (3) of the ten (10) least accessible wards to primary healthcare services are also located in Lokoja LGA. These are wards 'DJ-32', 'CT-33' and 'CX-17', which rank 334th, 336th and 337th respectively (of 341 wards), as shown in Table 6-4. On

[64] Values of -3 > Z-Score > 3 are negative or positive outliers respectively.

[65] See Figure 6-1 for relevant contextual information.

the one hand, this suggests staggering microscale inequalities in SPAI, such that Lokoja LGA tends to exhibit by far more small-area spatial variations in SPAI than most other LGAs (see Figure 6-12 and Figure 6-13). On the other hand, this brings to the fore the potential effects of zonal shape on inequalities, as discussed in Section 3.3.1 and Chapter 4. For instance, from Figure 6-1[66], Lokoja LGA has an oblong shape that stretches along the southern flank of River Niger all the way to the extreme North-West boundary of the state. However, Lokoja town, which is the state capital, is at the extreme southern vertex of the same LGA, at the confluence of rivers Niger and Benue. This type of problem is partly resolved in the LGA zone design operation of Section 4.3.2. Despite respecting extant senatorial district demarcations (which apparently undermines the optimality of the outcome), the zone design simulations in Figure 4-9A and Figure 4-10(C, D and E) produce more compact zones for the Lokoja LGA region. There, the extant Lokoja LGA is split into two, with Lokoja town belonging in a different synthetic LGA to the localities in the extreme far North-West region of the extant Lokoja LGA, which is now shown (in Figure 6-15) to suffer extreme inaccessibility to primary healthcare services. In this way, the extreme spatial inaccessibility of primary healthcare in that region would become apparent even if data are aggregated at (synthetic) LGA scales, thereby making it possible for such deprived areas to receive appropriate remedial interventions from relevant public authorities. This is a vivid manifestation of the MAUP and other associated zoning problems discussed in Section 3.3.1.2.

Furthermore, with both state and LGA administrative capitals situated in Lokoja town, most public facilities (including hospitals) allocated to Lokoja LGA are situated in Lokoja town to the extreme disadvantage of other far-flung localities in the LGA. This also highlights the enormous importance of the small-area analysis conducted in the current study, in that this pattern of dire disparity in spatial accessibility of primary healthcare in Lokoja LGA is totally concealed or attenuated if the same analysis is performed at only the LGA level. For instance, (weighted) mean SPAIs computed for LGA and Senatorial Districts in Section 6.3.3.2 shows that the extremely high SPAI scores of wards in Lokoja town (shown in Table 6-3) effectively counterbalances the effects of wards with extremely poor SPAIs in the same LGA, which also may not be very populated (see Table 6-5). Thus, despite containing three (3) of the ten (10)

[66] see also Figure 4-7

least accessible wards in the study area, Lokoja is the 5th LGA most accessible to primary healthcare personnel in the study area (of 21 the LGAs).

This sort of concealment both creates and perpetuates the precarious condition of disadvantaged localities, in that by being invisible to relevant policymakers and planners, their chances of ever receiving remedial help are extremely bleak. In this sense, small-area analysis of relevant geographical phenomena like healthcare access can be construed as an analytical approach capable of empowering and enfranchising (‘give voice’ to), and therefore emancipating localized pockets of socio-spatial disadvantage wherever they exist, by accentuating their precarious conditions. On the flipside, analyses at coarse spatial scales not only oppress disadvantaged or marginalized localities (by concealing their precarious condition) but also further privilege advantaged groups by directing interventionists to large regions wherein privileged/influential individuals may siphon or conscript relevant benefits to themselves or their already advantaged localities. Indeed, this partly explains some of the problems with international developmental assistance to Nigeria, such as Development Assistance for Health (DAH). This also lends support to the **inverse-equity hypothesis** (Victora *et al.*, 2000).

At the senatorial district level, despite containing eight (8) of the ten (10) most accessible wards to healthcare services (see Table 6-4), Kogi West also has seven (7) of the ten (10) least accessible wards, which are located mostly in Kabba/Bunu and Lokoja LGAs. Nevertheless, none of the least accessible wards to healthcare are outliers. Furthermore, Ajaokuta LGA, which is the 4th most accessible ward, also features prominently amongst the ten (10) least accessible wards as the 333rd and 338th. This suggests that there is extreme small-area spatial inequality of healthcare accessibility in Kogi West Senatorial District as well as in Ajaokuta LGA (in Kogi Central Senatorial District). Boxplots of small-area variations in the SPAIs of primary healthcare services within LGAs in the study area are presented in Figure 6-11, Figure 6-12 and Figure 6-13. These show that there are substantial variations in the interquartile range as well as median values of SPAI within each LGA, with LGAs in Kogi West possessing the widest interquartile ranges (especially in Lokoja) and LGAs in Kogi Central having the narrowest interquartile ranges (especially Okene and Ogori/Magongo). These imply that various spatial patterns of variations/inequalities in SPAI are observable at various spatial scales. In some instances, these spatial variations are dominant at the scale of senatorial districts (as with the case of Kogi West), whereas, in other instances, these variations manifest at the scale of LGAs (as with the case of Lokoja and Ajaokuta). Put differently, there are non-stationary scale-dependent spatial variations in SPAIs in the study area (Haining, 2003; Pfeiffer *et al.*, 2008, p. 14; Jade, 2019). Thus, spatial analytics of relevant phenomena like PHC accessibility is best performed at multiple spatial scales. Furthermore, determining an appropriate scale for analyzing variations in the spatial accessibility of healthcare services is a matter of critical importance.

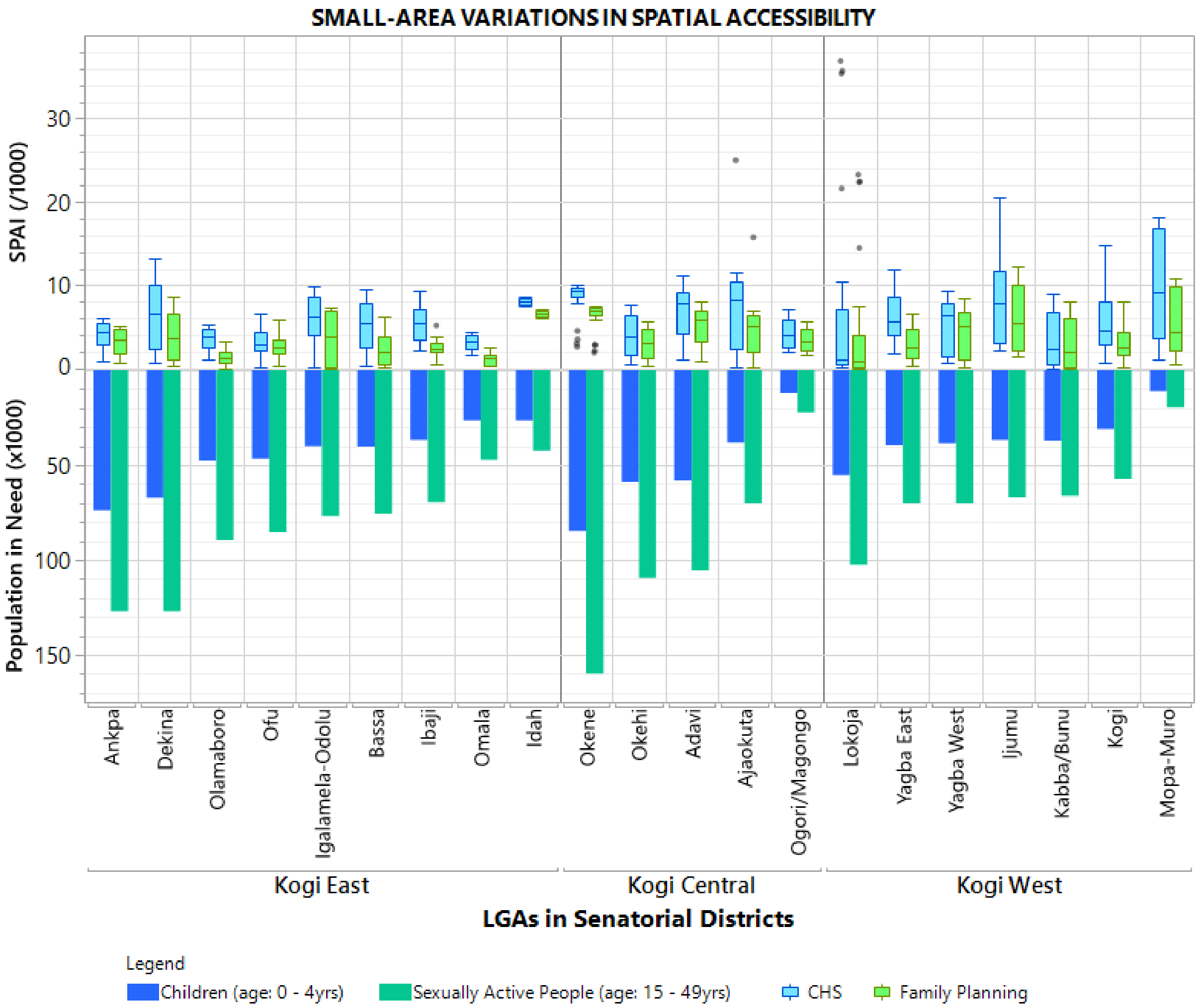


Figure 6-11 Small-Area variations in SPAIs of CHS and family planning services within LGAs in Kogi State.

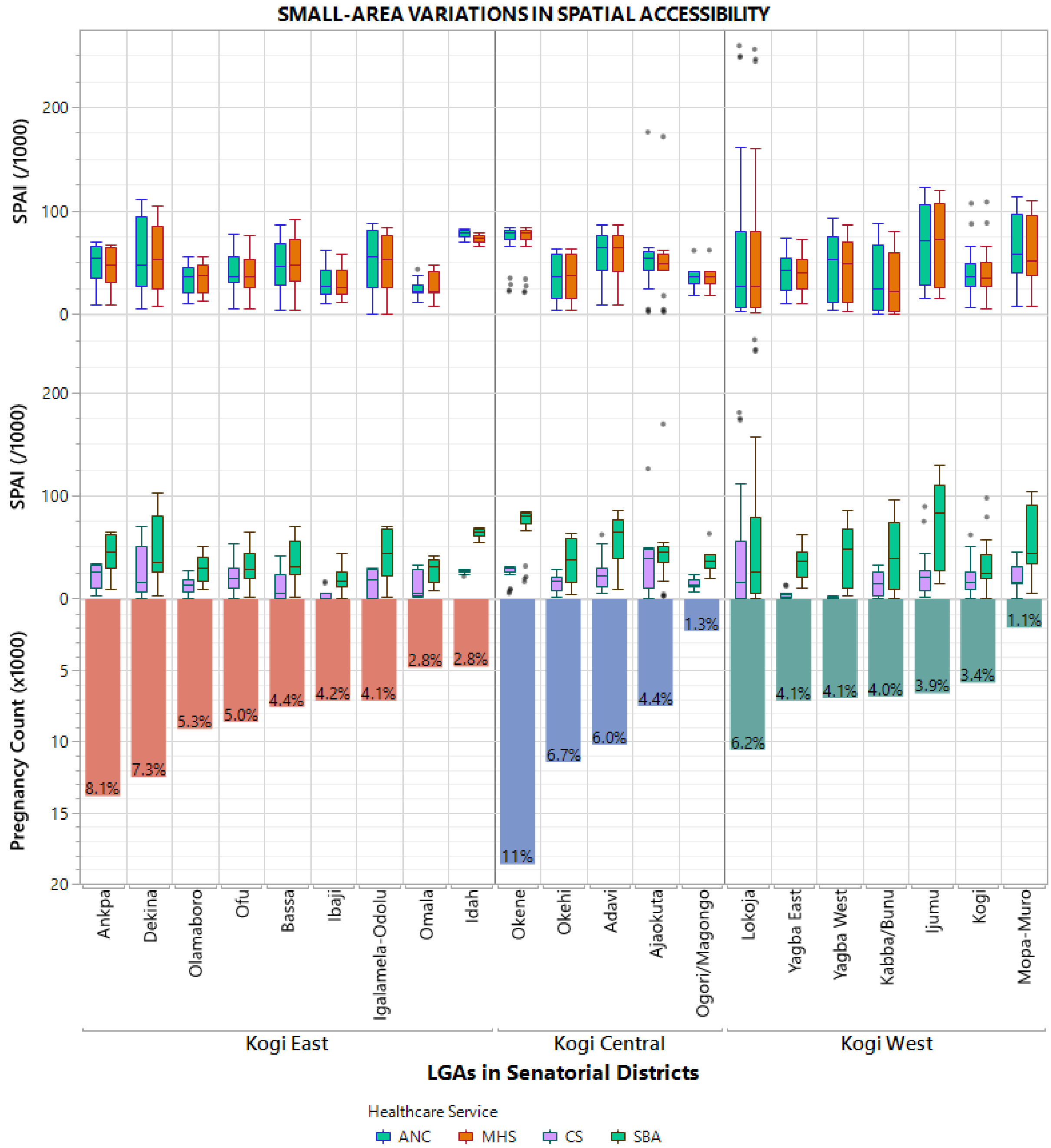


Figure 6-12 Small-Area Variations in SPAIs of pregnancy-related healthcare services (i.e. ANC, MHS, CS and SBA) within LGAs in Kogi State.

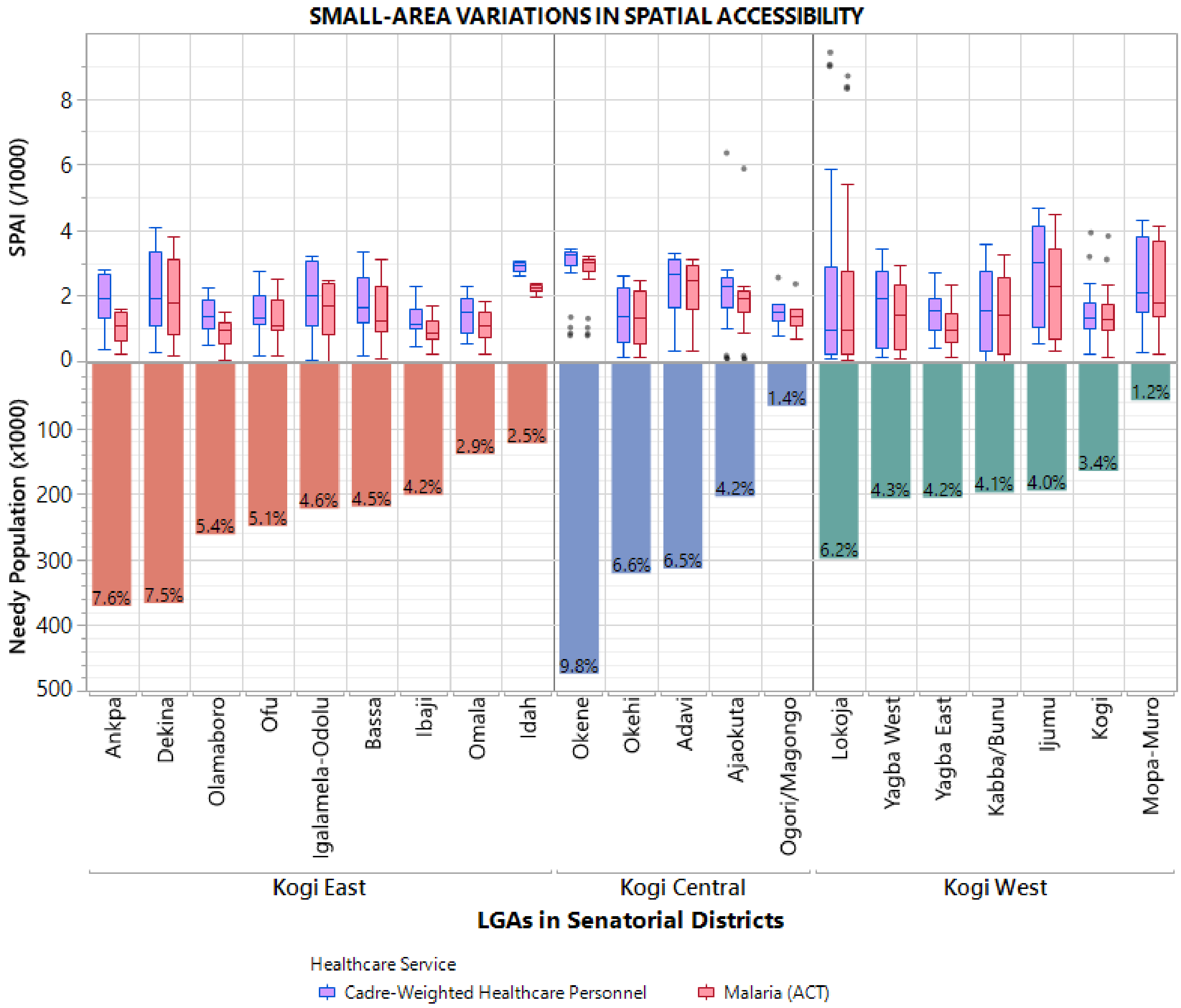


Figure 6-13 Small-Area variations in SPAIs of healthcare personnel and malaria treatment services within LGAs in Kogi State.

An overview of small-area spatial patterns of accessibility of baseline healthcare services discussed in the foregoing paragraphs is presented in Figure 6-14, while the mean spatial accessibility (of all baseline healthcare services), as well as their associated z-scores, is mapped in Figure 6-15. Except for CHS which has six (6) wards in its best accessibility category, all other accessibility maps have only five (5) wards in their best category. Apparently, these are the five positive outliers that rank 1st to 5th in Table 6-3, none of which is in Kogi East, as discussed in a preceding paragraph. These maps of SPAI, which is a metric of the approximate quantity of primary healthcare services that can be reached per thousand need in each small-area, also shows the number of synthetic wards that belong in each SPAI category (in square brackets). In this way, the most dominant and least popular SPAI category is known, since these maps are borderless choropleths at the synthetic ward level[67], classified using jenks class breaks. For instance, the most popular SPAI category (the modal category) of C-Section in Figure 6-14C is the 0 – 8.44 category, which accounts for 36.91% of wards (i.e. 126) in the study area.

Overall, Figure 6-15 suggests that even though none of the best categories for SPAI and SPAZ are in Kogi East, the same senatorial district also does not have many wards in the most disadvantaged accessibility group. Rather, the majority of wards in Kogi East tend to be in the middle category (which is the mean category) as well as the 4th category, which is slightly less than the mean category. This is very likely a result of the relatively more even spread of population (and by extension, relevant need variables) in Kogi East, compared to the other senatorial districts whose population tend to cluster more around a few urban centres as a result of cultural or physical/topographical reasons[68]. For instance, many areas in Kogi Central are known to either be very rocky or mountainous and are therefore uninhabitable. In this sense, while a difficult topography may have been received in a bad light in Kogi Central, for preventing settlement sprawl (and maybe other beneficial activities, like agriculture), it has caused a concentration of population in few conducive urbanized localities. This positive effect is the agglomeration effect of population clustering, one of which is improved accessibility to public services like healthcare.

[67] Even if the borders of analytical wards are shown, not only are some wards extremely small, but they are also too numerous to be differentiated and counted manually.

[68] Improving the spatial accessibility of PHC services in Kogi East may therefore be a matter of increasing the number of healthcare personnel as well as the infrastructural quality of existing facilities. Improving the quality of some key roads would also be beneficial, especially roads that connect rural remote localities to central towns in the region. These aspects are often ignored in studies on spatial accessibility (in Nigeria) which usually tend to propose the citing of new hospitals as the main remedial intervention. This is discussed further in Chapter 7.

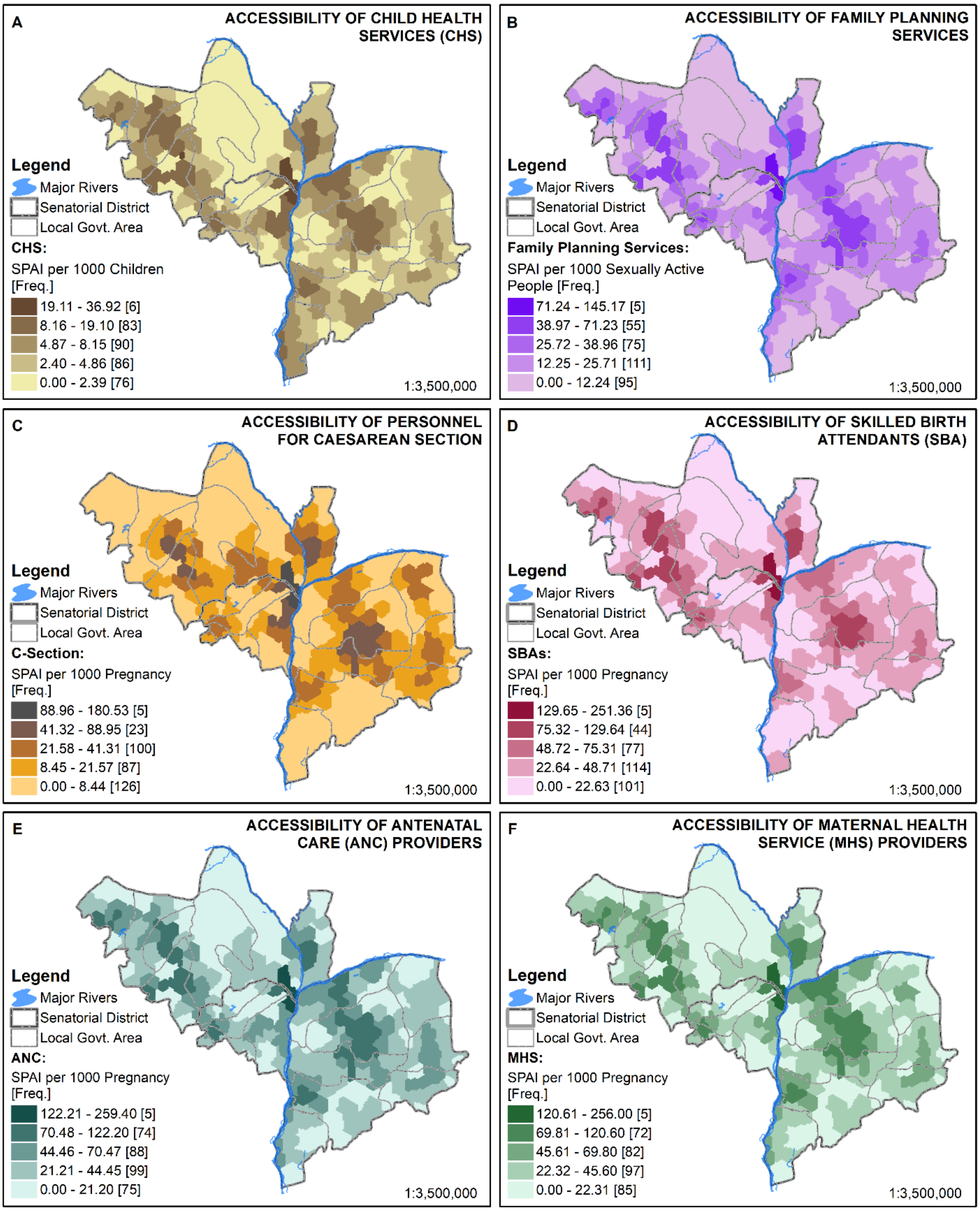


Figure 6-14 The Spatial Accessibility of CHS, SBA, CS, ANC, MHS and Family Planning Services. These choropleth maps were produced using the natural breaks (jenks) of the respective SPAIs of the ONN-G2SFCA index (whose coefficient for distance-decay weighting is 15 minutes).

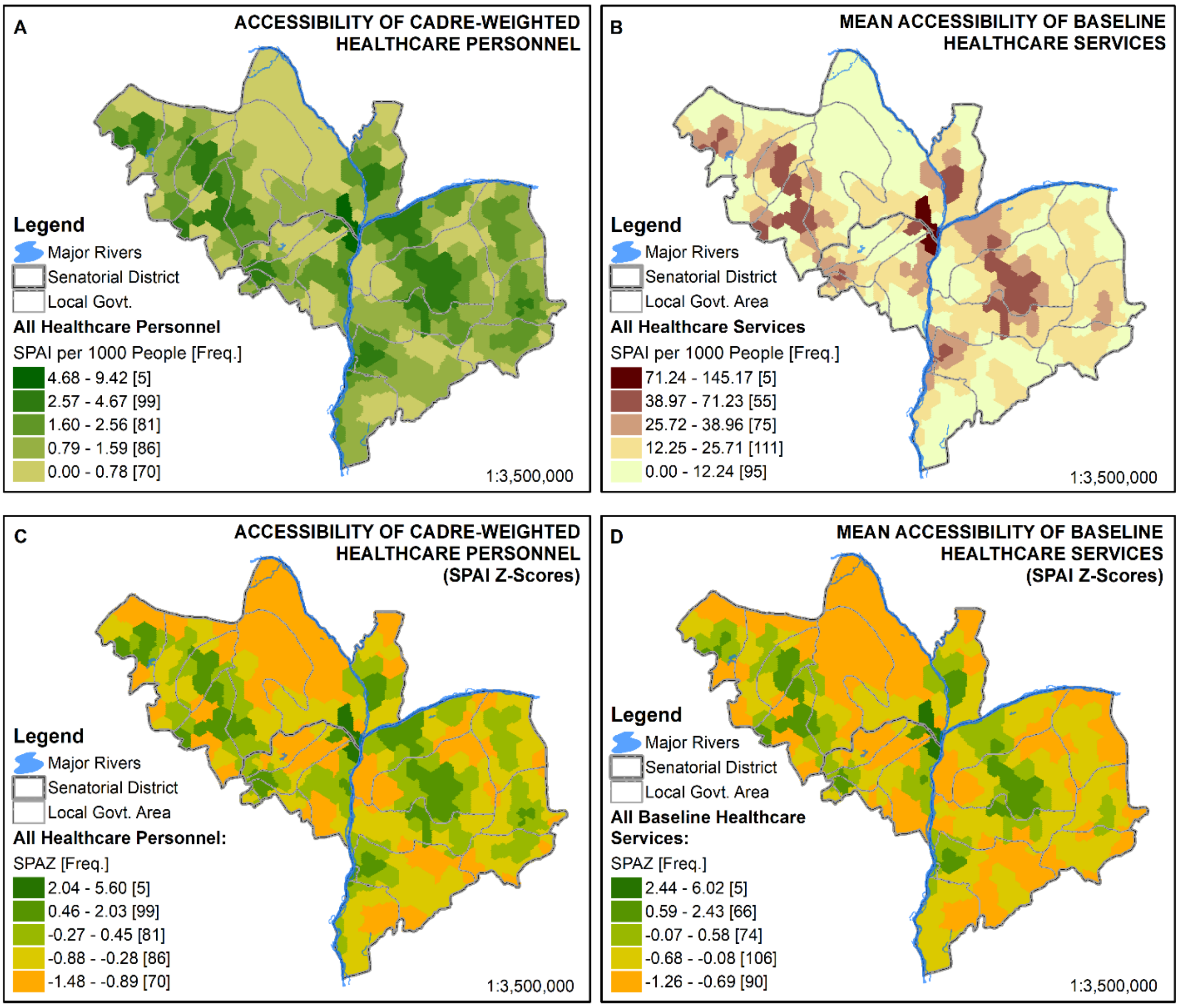


Figure 6-15 (A) SPAI of personnel-weighted healthcare regardless of service-specific availability, while (C) is the SPAZ variant. (B) The mean of service-specific SPAIs of all baseline service in a study area, while (D) is the associated SPAZ variation.

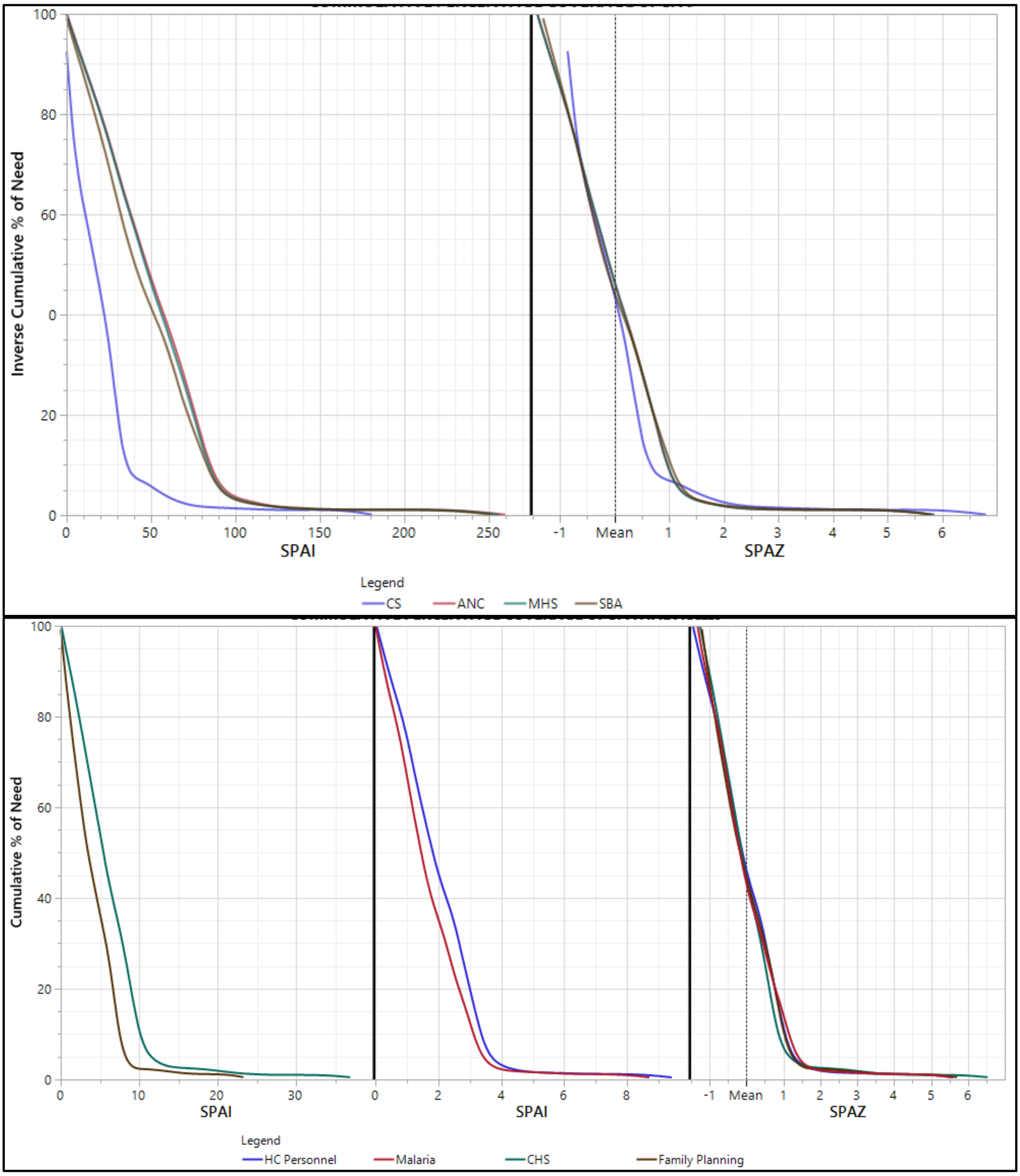


Figure 6-16 Ogives showing the cumulative percentage of need population with less than or equal to various SPAI and SPAZ values for each PHC service in Kogi State.

Figure 6-14 and Figure 6-15 are complemented by Figure 6-16 and Figure 6-18, which show the cumulative percentage of need population with less than or equal to various SPAI (and SPAZ) values of PHC services in Kogi State. Figure 6-16 shows that overall, pregnancy-related PHC services (i.e. C-S, ANC, MHS and SBA) have better SPAI values than the other PHC services, mainly because the need population for these services tend to be much less than that of the remaining PHC services while service supply remains relatively the same. Consequently, aside from extreme positive accessibility outliers, the maximum SPAI for pregnancy-related PHC services is about 130 (per 1000 people), whereas the maximum SPAI values for both PHC personnel and Malaria ACT treatment is about 5 (per 1000 people). For CHS and family planning services, the maximum SPAI value is about 15 (per 1000 people), aside from the positive extreme outliers. Nevertheless, it is apparent that C-S service has much lower SPAI values than the other pregnancy-related services, which all have similar SPAI ogive curves, as shown in Figure 6-16. Not only do these findings suggest a need to upgrade the accessibility of PHC personnel (and malaria ACT treatment) in the study area, but amongst pregnancy-related PHC services, C-S service should also be given prioritized attention by relevant public authorities.

6.3.3.2 Spatial Accessibility Indices Aggregated at Coarse Spatial Scales: LGAs and Senatorial Districts

In this section, the aggregate spatial accessibility index per LGA is presented in Table 6-5 and discussed. This is corroborated with the boxplots of Figure 6-17 (for only pregnancy-related services), which show statistical measures of dispersion and centrality of SPAIs for each Senatorial District based on their inherent LGAs. Specifically, the interquartile ranges and median values of the senatorial district are shown based on the weighted mean SPAIs of their respective LGAs.

Despite containing three (3) of the ten (10) least accessible wards as well as four (4) of the ten (10) most accessible synthetic wards to PHC in Kogi State (see Table 6-4), Table 6-5 shows that Lokoja LGA has the best mean SPAI of all primary healthcare services, as well as the 5th best mean accessibility to healthcare personnel in the study area. This is a result of the counterbalancing effect of its top four (4) most accessible wards, which are all positive outliers, as shown in Table 6-4. Ranked in descending order of average accessibility to primary healthcare personnel, Table 6-5 lists LGAs according to their level of accessibility. The three (3) most accessible and least accessible LGAs based on each baseline healthcare service are also highlighted in green and red respectively. It is interesting that the three (3) most accessible LGAs (to healthcare personnel) are contained in each senatorial district; however, all three least accessible LGAs are in Kogi East. It is therefore not surprising that Kogi East has the least PHC accessibility, as shown in Table 6-6, while Kogi Central has the best accessibility to PHC services in the study area.

Even though these best or worst three (3) LGAs in terms of accessibility to healthcare personnel also rank similarly, when individual services are considered, a few service-specific SPAIs deviate markedly from the overall rank order of LGAs. Particular deviant services are C-Section, Child Health Services and Family Planning services as illustrated by the scattered green and/or red shades on their respective columns in Table 6-5. Although it is not clear why these particular services notably deviate from the overall accessibility pattern in the study area, this accentuates the importance of service-specific analysis of PHC spatial accessibility in LMICs. Furthermore, aggregation at LGA greatly masks local disparities in spatial accessibility, which may be striking at the small-area scales, as discussed in the preceding section (UNDP Nigeria, 2016, p. 61; AbouZahr *et al.*, 2017, p. 12). For instance, in terms of accessibility of healthcare personnel (regardless of service-specificity), the best LGA (i.e. Idah) has 2.9 personnel per 1,000 people, whilst the least accessible LGA (i.e. Ibaji) has 1.24 personnel per 1,000 people[69]. This suggests that the most accessible LGA has about double the number of healthcare personnel of the least accessible LGA; hence, this may not arouse so much concern from relevant public authorities, in terms of inequality considerations. because of the possibility of more serious inequalities in the study area, an observed disparity in the order of one (1) is to two (2) could be overlooked, since there is a tendency for much worse cases. However, analysis at the small-area scale shows acute disparities in SPAIs, which would likely be concerning to relevant policymakers.

[69] When SPAI is analyzed at the small-area level, the best and worst accessible localities in the study area are in Kogi West. However, once SPAIs are (aggregated and) analyzed at the LGA-scale, the best and worst accessible LGAs become located in Kogi East.

Table 6-5 Mean spatial accessibility index per LGA (weighted by relevant demand variables of the analytical wards[70])

Senatorial District	LGA	No of synth wards	HC Personnel	CS	ANC	CHS	Family Planning	Malaria (ACT)	MHS	SBA	Mean SPAI of all Services	Rank (by Personnel SPAI)
Kogi East	Idah	7	2.90	26.26	77.83	8.18	6.65	2.24	73.30	63.32	36.82	1st
Kogi Central	Okene	26	2.88	25.70	71.17	8.53	6.38	2.70	71.23	71.17	36.70	2nd
Kogi West	Ijumu	14	2.72	27.88	66.36	9.17	6.36	2.36	66.70	72.14	35.85	3rd
Kogi West	Mopa-Muro	5	2.51	22.75	66.31	10.63	6.00	2.34	63.37	58.64	32.86	4th
Kogi West	Lokoja	23	2.41	45.73	68.02	8.38	5.97	2.21	67.22	65.30	37.55	5th
Kogi Central	Adavi	21	2.24	22.87	54.84	6.65	5.06	2.10	54.88	55.02	28.77	6th
Kogi East	Dekina	26	2.18	26.91	58.79	6.67	4.31	1.99	56.23	48.78	29.10	7th
Kogi Central	Ajaokuta	15	2.10	33.33	51.30	8.07	5.30	1.82	48.17	43.42	27.34	8th
Kogi East	Igalamela-Odolu	16	1.97	15.24	50.00	6.16	4.01	1.52	48.03	42.42	23.91	9th
Kogi East	Ankpa	26	1.92	21.33	49.15	4.41	3.30	1.07	46.93	45.22	24.49	10th
Kogi West	Yagba West	15	1.88	1.17	50.40	5.17	4.61	1.56	47.26	46.10	22.32	11th
Kogi East	Bassa	16	1.70	11.95	45.10	5.20	2.32	1.44	47.20	34.01	21.03	12th
Kogi West	Kogi	13	1.60	20.19	42.55	5.90	3.11	1.55	42.41	34.38	21.44	13th
Kogi West	Kabba/Bunu	15	1.55	14.47	35.51	3.55	3.25	1.42	31.60	40.04	18.55	14th
Kogi East	Ofu	18	1.54	21.78	42.52	3.37	2.83	1.34	41.36	32.68	20.84	15th
Kogi Central	Ogori/Magongo	5	1.51	14.67	37.06	3.98	3.31	1.39	37.32	38.35	19.44	16th
Kogi West	Yagba East	14	1.49	4.42	39.75	6.54	3.08	1.06	39.31	34.44	18.37	17th
Kogi Central	Okehi	22	1.45	15.00	36.70	4.14	3.27	1.36	36.68	36.98	19.16	18th
Kogi East	Omalla	10	1.42	12.82	24.46	3.14	1.14	1.12	28.22	26.57	13.92	19th
Kogi East	Olamaboro	19	1.33	12.87	33.48	3.70	1.40	0.90	34.53	28.66	16.51	20th
Kogi East	Ibaji	15	1.24	2.72	31.11	5.58	2.49	0.90	30.65	18.58	13.15	21st

[70] Average service accessibility is the mean of all the weighted means since different service-specific variables are used, this is equivalent to the output from the 3SFCA algorithm.

Table 6-6 Mean spatial accessibility index per Senatorial District (weighted by relevant demand variables of the wards)

Senatorial District	No. of Synthetic Wards	HC Personnel	CS	ANC	CHS	Family Planning	Malaria	MHS	SBA	Mean SPAI of all Services	Rank
Kogi Central	89	2.22	23.33	55.45	6.78	5.05	2.06	55.02	54.43	28.87	1st
Kogi West	99	2.01	21.13	52.58	6.78	4.61	1.76	51.18	50.61	26.95	2nd
Kogi East	153	1.79	17.78	46.29	5.10	3.14	1.37	45.39	38.42	22.50	3rd

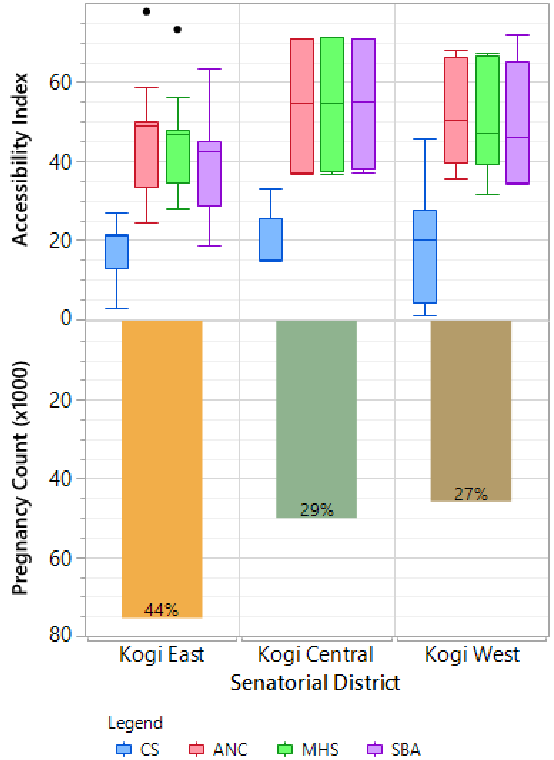


Figure 6-17 LGA-level variations in mean SPAIs of the pregnancy-related healthcare services within Senatorial Districts of Kogi State.

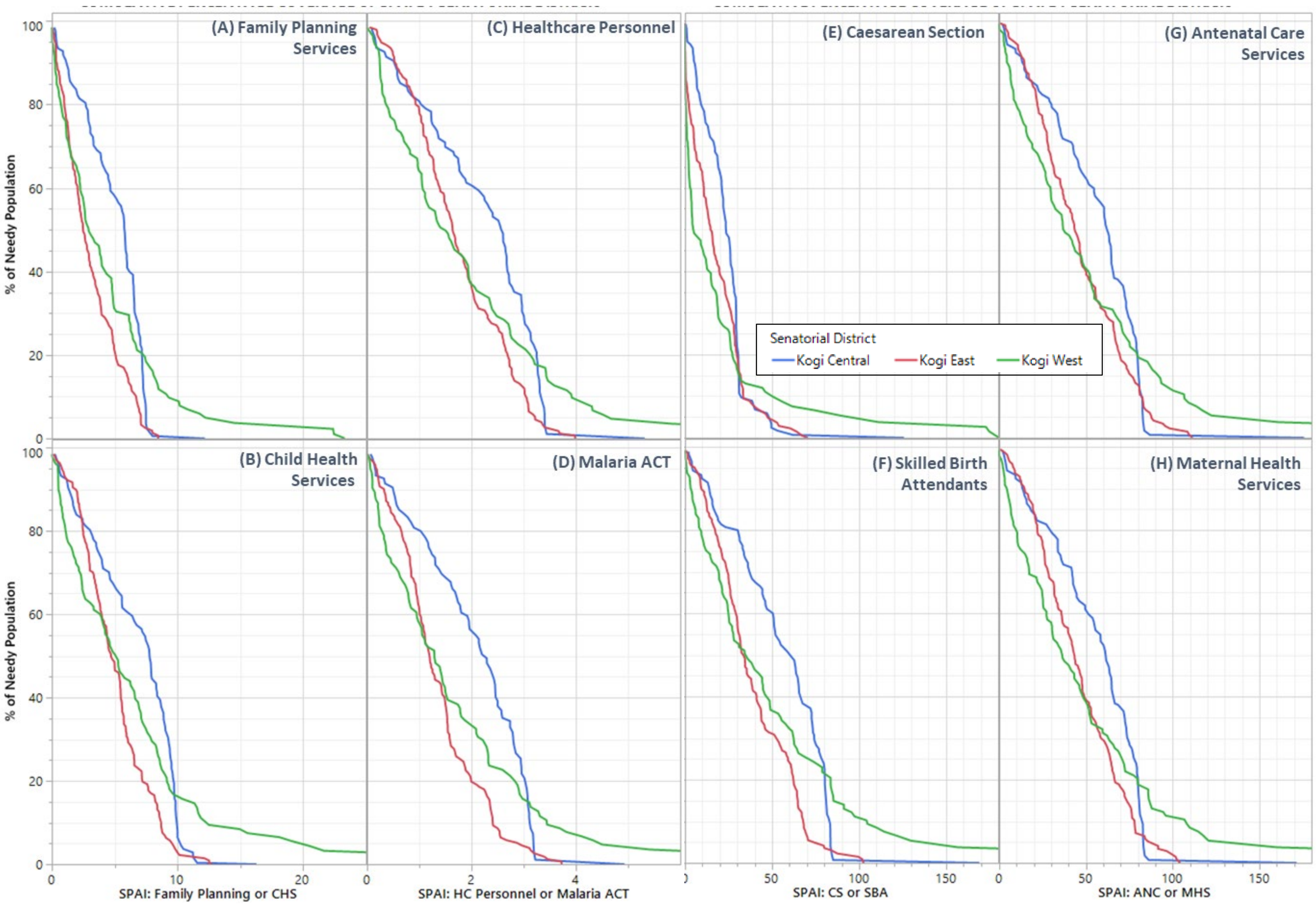


Figure 6-18 Ogives comparing the cumulative percentage of need population with less than or equal to various SPAI values for PHC services in the three Senatorial Districts of Kogi State.

The degree of disparity at the LGA level also varies by service type. It is worse for some specific services like SBA, Family Planning, with C-Section tending to possess the most acute disparity. The small-area corollary of the foregoing is shown in Table 6-3 in part. There, it can be seen that in the synthetic ward with the second worst PHC accessibility, 'CZ-54' (in Kabba/Bunu LGA), only about four (4) personnel would be accessible per 100,000 people; whereas in the synthetic ward with the best accessibility, 'FN-99' (in Lokoja LGA), about 942 personnel would be accessible per 100,000 people. When analyzing SPAI at the LGA-scale, the three LGAs with the worst accessibility (i.e. Olamaboro, Omalla and Ibaji, all of which are in Kogi East as shown in Table 6-5) do not feature amongst LGAs containing ten (10) of the least accessible wards in Kogi State (see Table 6-3). This is another aspect of spatial misinformation that results from aggregating spatial data at coarse spatial scales, one of which is discussed in Section 6.3.3.1 (in which extremely inaccessible localities are concealed within very accessible LGAs like Lokoja). In this case, results of accessibility analysis at the LGA aggregation level would point policymakers and interventionists to LGAs that do not contain any of the worst cases in the study area. Remediating spatial accessibility at the LGA level, with priority attention to poorly served LGAs implies that inequalities in accessibility at the small-area level may therefore be aggravated by neglecting the most inaccessible small-areas. Similarly, focusing on analysis results aggregated at the level of senatorial districts, policymakers and interventionists are likely to focus on Kogi East to the detriment of the other two senatorial districts. Even though analysis at LGA and Senatorial district aggregation levels both point to Kogi East as being the laggard in terms of spatial accessibility to primary healthcare in Kogi State (see Table 6-5 and Table 6-6), none of the ten (10) least accessible wards are in Kogi East (see Table 6-3). This implies that remedial policies and interventions which are based exclusively on findings at the LGA spatial scale are likely to perpetuate spatial inequalities in the study area, the notion of intervention-generated inequity (Lehne and Bolte, 2016; Eslava-Schmalbach *et al.*, 2019, p. 8). This reiterates the necessity of performing policy-relevant spatial analysis at appropriate small-area spatial scales while accounting for the effects of data aggregation across multiple spatial scales (Gentili *et al.*, 2015). The importance of developing and utilizing bespoke analytical small-area zones wherever existing zoning systems are unoptimized or outdated (as is usually the case in LMICs like the study area) is also foregrounded.

Further aspects of variations in the accessibility of PHC services amongst the three (3) senatorial districts in Kogi State are revealed in Figure 6-18 with the aid of ogives. The ogives both reiterate the finding that Kogi Central (represented by blue curves) generally has better spatial accessibility to PHC services than the other senatorial districts, and suggest that there are fewer disparities in the same district. The only exceptions to this are the synthetic wards that are extremely positive outliers in Kogi West, which constitute less than 5% of the population of the same district, which is essentially in Lokoja Town. As explained briefly in Section 6.3.3.1 above, Kogi Central has a very rocky and rugged topography which, although discourages agricultural activities and other potentially beneficial socioeconomic activities, is also instrumental to constricting the district's population within small, densely populated locations. As a result of this small settlement footprint and the consequent high population density, servicing this district with basic social amenities, including PHC, is relatively easier for public authorities (Humphreys and Smith, 2009, p. 74; Burkey, 2012, p. 793). In addition, private service providers are incentivised by the dense population in the same district. On the flipside, although both Kogi East and Kogi Central senatorial districts are laggards which have similar patterns of PHC accessibility as depicted by the red and blue curves respectively in Figure 6-18; Kogi East has worse accessibility than Kogi West since much less percentage of need population have high SPAI values. Even though Table 4-4 shows that Kogi East is a little more densely populated than Kogi West, this has not translated into accessibility advantages, especially because of the tendency of many extant PHC facilities in Kogi East to be non-functional as a result of their total lack of PHC personnel. This is discussed in Section 6.3.2 and shown in Figure 6-9.

6.4 Summary and Conclusion

This chapter innovatively resolves a myriad of concerns related to robust spatial analytics of PHC accessibility in data-scarce contexts like Nigeria, thereby demonstrating that in LMICs, it is possible to comprehensively analyze spatial accessibility at appropriate microscale levels. In this regard, a bespoke small-area analytical zoning system (with an optimum population of 15,000 people) is utilized in order to overcome the constraints of having to use the extremely coarse spatial scale (the LGA) of population data which is typically the most disaggregated spatial data available in Nigeria. Not only is it advisable to analyze spatial accessibility at very disaggregated spatial scales (i.e. small-area zones) that are fit for purpose (Gentili *et al.*, 2015), but the use of optimized analytical zoning systems is also invaluable in minimizing most problems of aggregate zonal population data, especially the pervasive MAUP and aggregation-induced errors (Gautam *et al.*, 2014, p. 12). Although the 2SFCA methods overcome many zone-related limitations of other container approaches and the ordinary FCA (highlighted in Section 3.3.3.4), its fidelity is still a function of the architecture of the zoning system utilized. The use of an optimized analytical zoning system that is also of appropriate spatial scale for primary healthcare services in the study area (i.e. 15,000 persons) means that the resulting floating and variable catchment areas are optimized by the same token. Furthermore, the use of smaller areal units of demand aggregation increases the localized accuracy of the accessibility index, even though this comes with increased computational complexity (McGrail, 2012, p. 2), as discussed in Section 3.3.1.

The precise specification of service supply and need quantities greatly enhances the accessibility indices derived from the 2SFCA methods; however, these are not adequately considered by many studies which often use generalizations of these (Langford and Higgs, 2006; McGrail and Humphreys, 2015; Plachkinova *et al.*, 2018, p. 293). For instance, in Nigeria, the mere presence of a healthcare facility does not signify the availability of essential services or personnel (Federal Ministry of Health (FMoH), 2016, p. 88). Even when a PHC service is provided by a healthcare facility, there are great differences in the service-delivery capacity of various hospitals, and there are also small-area variations in these differences. For example, C-Section and SBA are much less available than other healthcare services in the study area. In a similar vein, even though Kogi East tends to contain a greater number of healthcare facilities, the per capita supply of personnel and services is not as much as would have been expected. It is therefore pertinent that among other things, analysis of spatial accessibility is sensitive to service availability, and not merely the availability of a healthcare facility, especially in developing contexts. Thus, in this study, service and personnel availability/supply is weighted by the number and cadre of healthcare personnel in each facility, similar to Ngui and Apparicio (2011).

This chapter also features relatively precise estimates of the need for each primary healthcare service in the study area. For example, in estimating the need for family planning services, the entire population of people of reproductive age (or married people) in the study area could serve as a rough estimate[71]. However, the population of people of reproductive age will

[71] The availability of family planning services in this study can be used as a rough proxy for HIV/AIDS-related services, with the assumption that HIV/AIDS-related services are components of family planning (or sexual and reproductive health) services. A composite indicator of sexual behaviour can also be derived from Chapter 5 as a surrogate of need for HIV/AIDS-related services in the study area.

underestimate the accessibility index to the disadvantage of localities with relatively higher proportion of sexually active people. On the other hand, the use of only married people neglects a large portion of the population who, though single, are sexually active. This will therefore lead to an over-estimation of accessibility, especially in localities with relatively low proportions of married people. Therefore, instead of using any of the foregoing rough estimates, the number of sexually active people in the study area, which is by far a more precise measure of need for family planning services, is utilized. This need population is derived from the SMM operation in Chapter 5, as explained in Section 3.3.2.

Thorough analyses of the spatial accessibility of baseline healthcare services are presented, by which robust small-area accessibility indices of the study area are discussed (for each primary healthcare service). This is accomplished with the aid of an advanced bespoke algorithm for calculating spatial accessibility indices, called the ONN-G2SFCA algorithm, based on realistic road network travel time by '*okada*', as discussed in Section 3.3.3.3. The size of variable catchment areas of this study varies as a function of the proximity of a fixed number of potential supply points (determined by an IDSO). This attempts to equalize the number of supply opportunities for each demand point. In this way, demand points with many proximal supply opportunities (typical of urban areas) will have smaller catchment areas compared to demand points with distal supply opportunities. In other words, in addition to using the Gaussian generalized distance-decay function, this study keeps the number of supply opportunities constant while varying the size of the catchment area of each demand point in order to adequately account for both distance- and opportunity-related effects of health-seeking behaviour based on the relative spatial patterns of demand and supply in the study area. This is a noteworthy improvement over other variants of 2SFCA implementations that vary catchment area sizes based on categorical variables like neighbourhood type, provider type, or type of areal context (i.e. rural or urban area) because characterizing these categorical zones as well as determining appropriate catchment sizes would prove contentious in many cases. These are explained in Section 3.3.3.5 and implemented in Section 6.3.3.1. The computed accessibility indices for the optimized small-area analytical wards are aggregated to large extant geographies in the study area, which makes it possible to ascribe contextual or aetiological meanings to the computed accessibility metrics.

It is not surprising that the top three most accessible synthetic wards, which are also positive outliers, are in Lokoja town (in Lokoja LGA). This is because Lokoja town is the administrative capital of both the LGA area and the state; consequently, it enjoys extreme contextual advantages in the form of political patronage/preferentialism[72]. It is, however, ironical that despite this, three (3) of the ten (10) least accessible wards to PHC services are also located in Lokoja LGA. On the one hand, this suggests severe microscale inequalities in SPAI; on the other hand, this brings to the fore the potential effects of suboptimal zoning systems on spatial inequalities. At the same time, the importance of small-area analysis of accessibility is also underscored in that the observed pattern of extreme disparity in spatial accessibility of healthcare in Lokoja LGA is attenuated or totally concealed if the analysis is performed at the LGA aggregation level. For instance, despite containing three (3) of the ten (10) least accessible wards in the study area, Lokoja LGA has the best mean SPAI of all PHC services, as well as the 5th best mean accessibility to healthcare personnel in the study area. This also implies that various spatial patterns of variations/inequalities in SPAI are observable at various spatial scales; therefore, spatial accessibility exhibits non-stationary scale-dependent spatial variations in every context (Cressie, 1993; Haining, 2003; Pfeiffer *et al.*, 2008, p. 14; Jade, 2019). Consequently, it important to analyze spatial accessibility at multiple spatial scales, including the appropriate microscale for a particular healthcare service (Gautam *et al.*, 2014; Gentili *et al.*, 2015).

This chapter reiterates the importance of zoning designs (especially the boundary and scale effects of the MAUP) to geographies of healthcare services in the study area and other similar contexts (Ricketts, 2009; Wong, 2009a; Gautam *et al.*, 2014; Cabrera-Barona *et al.*, 2018). It also demonstrates that only analyses at small-area spatial scales are capable of empowering minority and disadvantaged subgroups by revealing and accentuating the enormity of their socioeconomic deprivation, a predicament that is often concealed when analyses are conducted at coarse spatial scales. Coarse or mesoscale analysis (such as LGA or senatorial district aggregation levels) would point policymakers and interventionists to large regions which may not contain any of the worst cases/localities in a study area. Microscale analysis can therefore be construed as an analytical approach capable of empowering and/or giving voice to (and therefore emancipating) people in localized pockets of socio-spatial

[72] See also Section 6.3.3.1

disadvantage (wherever this may exist), by accentuating their precarious conditions. On the flipside, analysis at coarse spatial scales not only oppresses disadvantaged or marginalized localities (by concealing their precarious condition), but also further privileges advantaged groups by directing interventionists to large regions. Influential/privileged individuals in these large regions can redirect interventions to their own selfish localities and/or interests. A mechanism capable of causing intervention-generated inequity is hereby foregrounded (Lehne and Bolte, 2016; Eslava-Schmalbach *et al.*, 2019, p. 8). In this sense, analysis at aggregate scales can be thought to entrench inequalities by further privileging already advantaged localities (UNDP Nigeria, 2016, p. 61; AbouZahr *et al.*, 2017, p. 12). This tends to partly explain why governments in LMICs like Nigeria are satisfied with analyses at coarse spatial scales since this seems to work to the benefit of the ruling class. This also lends support to the inverse-equity hypothesis (Victora et al., 2000). Socio-spatial analysis at appropriate small-area scales is therefore the most useful approach for local-level and equity-sensitive planning, policy-making and intervention in every context (AbouZahr *et al.*, 2017, p. 12).

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Chapter 7. Healthcare Experiences and Perspectives in Extreme Medically Underserved Areas (eMUAs): A Qualitative Exploration

7.1 Background

The focus of this chapter is on perceived need and perceived accessibility because in addition to the objective metrics in preceding chapters, these subjective facets interact to influence healthcare utilization in every context as explained by many theoretical models, such as Anderson Behavioural Model (ABM) (Anderson, 1968; Anderson, 1973), the Health Beliefs Model (Rosenstock, 1974; Rosenstock *et al.*, 1988) and the three-delays model (Thaddeus and Maine, 1994, p. 6). However, their actual manifestation and explanatory factors may be different for social and/or spatial groups in various contexts, including the study area, Nigeria (Igwe *et al.*, 2015). This study is patient-centred since only perspectives of potential healthcare users (in extreme Medically Underserved Areas (eMUAs)) are considered (Berwick, 2009; Fortney *et al.*, 2011). Thus, the emphasis of this chapter is on experienced and/or perceived demand-side deterrents of healthcare accessibility. Supply-side impediments are considered only if they are invoked by potential users, in which case they are mediators.

In trying to understand and explain perceived accessibility to healthcare in places identified (quantitatively) with extreme healthcare deprivation, it is very helpful to consider the flipside – barriers to care (Fortney *et al.*, 2011, p. 642). This is synonymous with looking at negative determinants or perceived deterrents of healthcare utilization in a given context[73] (O'Connell *et al.*, 2015, p. 5). In this way, people in eMUAs are expected to report/narrate/explain multiple and more intense experiences of barriers to care compared to places that have appreciable accessibility to healthcare. This is also an intuitive approach because the literature is replete with analytical frameworks and literature reviews of access barriers to healthcare services (Grimes *et al.*, 2011; Jacobs *et al.*, 2012; Kyei-Nimakoh *et al.*, 2017; Bright and Kuper, 2018; Bright *et al.*, 2018b; Geleto *et al.*, 2018).

In this chapter, I paint a nuanced picture of people's experiences of spatial accessibility in eMUAs. In other words, the perceived accessibility of healthcare in eMUAs is explored with a focus on self-reported and subjective dimensions (Fortney *et al.*, 2011, p. 642). In so doing, relevant perspectives and desires of participants are also considered. The emphasis of this

[73] Literature on 'determinants of access/utilization' often use quantitative methods, while literature on 'barriers of access/utilization' (or facilitators) often use qualitative methods.

doctoral research project is spatial accessibility; therefore, themes that are directly associated with participants' physical accessibility to primary healthcare are the main concerns of this chapter. Other themes are considered to the extent that they are implicated by core spatial accessibility themes. In so doing, this chapter corroborates and/or validates some of the findings from previous chapters before delving into aspatial (or socioeconomic and cultural) dimensions of access, which may have been raised by research participants. In short, through an exploration of peoples' experiences in trying to obtain healthcare, this chapter addresses the question: what does a lack of spatial accessibility to primary healthcare mean to people in extreme MUAs, and how does place mediate these experiences? In other words, this chapter seeks to answer the question: how do perceptions and experiences of accessibility vary across extreme MUAs in the three sociocultural contexts of the study area? To this end, auxiliary questions are as follows:

- What are the recognized healthcare needs in the study area; how and why do they vary by local contexts?
- In what ways do difficulties in accessibility manifest in the experiences of people in MUAs, across various contexts?
- What interventions do participants crave, and why?

Additional discussions on conceptual frameworks of access in the current chapter develop from Section 2.3, wherein some of these frameworks were first explored (albeit without adequate attention to the subjective facets of the current chapter). The analyses in this thesis comprise two main strands: (1) the concept of healthcare need, which is made up of objective and subjective (i.e. perceived) dimensions (Bradshaw, 1972b, 2005; Oliver and Mossialos, 2004) and (2) the concept of potential access[74] has both objective and subjective (i.e. perceived) dimensions which in turn comprises spatial and aspatial (i.e. socio-cultural) facets (Khan, 1992; Guagliardo, 2004). Whereas these concepts are explained in Section 2.3, the analysis of objective need is the subject of Chapter 5 and parts of Chapter 6, while objective spatial accessibility (which implies potential spatial access) is the SPAI metric computed by the G2SFCA method in Chapter 6. This chapter corroborates the foregoing chapters by analyzing and explicating the perceived need and perceived accessibility in the study area. The primary vehicle for analyzing perceived accessibility is the 'three-delays model' (Thaddeus and Maine,

[74] In this study, potential healthcare access is synonymous with healthcare accessibility.

1994), because unlike other competing frameworks, it explicates both perceived healthcare need and accessibility with adequate attentiveness to spatial and aspatial aspects as well as temporal/procedural aspects of care-seeking (Myers *et al.*, 2015), as illustrated in Figure 7-1. Spatial accessibility synthesizes travel-related disincentives and service availability (i.e. per capita supply), all of which constitute Phase II delays of the three-delays model (McGrail, 2012, p. 2; Hu *et al.*, 2013, p. 3; Pan *et al.*, 2015, p. 261). This is also consistent with the seminal theoretical framework of Tanahashi (1978), which uses the concept, 'geographic coverage'. Travel-related disincentives feature difficulties associated with reaching the location of a facility, and the potential reduction in service utilization that is likely to result. These dis-incentives include travel time/distance, transportation cost, convenience, availability and quality of transportation medium and road infrastructure amongst other factors. Having reached a healthcare facility, service availability and quality considerations come into effect. They typically manifest as long waiting times and queues at PHC facilities which suggest a shortage of service provision. Ineffective or unsatisfactory treatment could also be provided at a healthcare facility. These constitute Phase III delays of the 'three-delays model'. Furthermore, anticipations of congestions and/or ineffectiveness at healthcare facilities could also act as a mediating factor (or impediment) to embarking on a journey to a facility, thereby informing a Phase I delay. Even though all phases of delays often work in concert, one or two phases are likely to be more prominent in a given locality, and the dominant phase of impediment(s) to healthcare access would vary from one context to another based on underlying sociocultural and/or geographical variations as demonstrated in this chapter.

It can therefore be seen that the five or six dimensions that constitute the popular conceptual frameworks of access that are often invoked by quantitative studies on healthcare access are encapsulated within Phase II delays of the three-delays model (Myers *et al.*, 2015, p. 256). According to Penchansky and Thomas (1981), these dimensions are: availability, accessibility, accommodation, affordability and acceptability. To these, there is a need to add 'awareness' as the sixth dimension (Saurman, 2016).

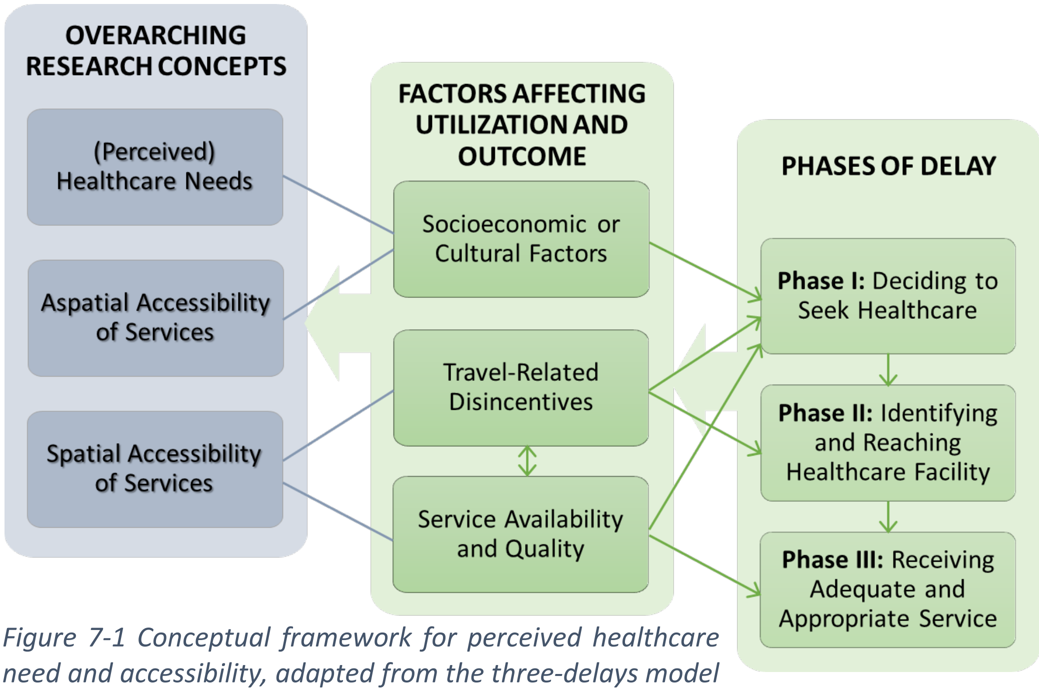

Figure 7-1 Conceptual framework for perceived healthcare need and accessibility, adapted from the three-delays model (Thaddeus and Maine, 1994, p. 1093)

In 'the three-delays model', discursive indicators of Phase I contain aspects of perceived healthcare needs while experiential indicators of Phase II and III feature pertinent *explanans*[75] of perceived accessibility. Based on this framing, perceived need and accessibility can be considered the main *explanandum*[76] of the current study, for which Phases I, II and III (of the 'three-delays model') are associated qualitative sub-*explanandum* respectively. However, while the three-delays model is the primary medium for exploring perceived need and accessibility to healthcare in the current study, it is corroborated by other relevant conceptual frameworks of healthcare access, especially Levesque *et al.* (2013) and Cabieses and Bird (2014). Both of these conceptual frameworks are introduced in Section 2.3.2 and illustrated in Figure 2-3 and Figure 2-4. The robustness of Levesque *et al.* (2013) is premised on the fact that it builds on previous seminal conceptual frameworks of access, including Penchansky and Thomas (1981), extending them in invaluable ways. For instance, although it does not feature an extensive explication of perceived need, unlike many other conceptual frameworks, it recognizes that perception of need is the commencement facet on the pathway of healthcare access (Levesque *et al.*, 2013, p. 4). In a similar vein, even though the 'three-delays model' as well as other conceptual frameworks of access recognize socio-cultural and geographical

[75] Explanans are tenable explanations for phenomena of interest.

[76] An explanandum is a phenomenon to be explained.

influences on access, they do not feature a rich contextual explanation like Cabieses and Bird (2014). Not only do Cabieses and Bird (2014) consider often ignored aspects of governance and political economy, but their main socio-spatial focus is also poor contexts (i.e. LMICs) and vulnerable population subgroups like the fieldwork sites. Therefore, this group of conceptual frameworks form an invaluable analytical toolkit for teasing out important contextual factors of the current study. In analyzing experiential indicators of access based on the primary qualitative data of this study, references are therefore made to the three-delays models, and sometimes to Levesque *et al.* (2013). However, for most analysis of contextual factors, Cabieses and Bird (2014) provide the main analytical framework.

The remainder of this chapter is organized as follows. Recognized health conditions, as well as healthcare preferences and the acceptability of various treatment options are considered next. These interact with each other as well as with the sub-themes of Section 7.3 to provide a holistic understanding of perceived accessibility, as explained by the lived experiences of research participants in eMUAs. Following this, contextual effects on both healthcare needs and accessibility are considered in Section 7.4. Remedial interventions desired by participants are discussed in Appendix B.3. Most of the communities mentioned in this chapter are mapped in Figure 6-1.

7.2 Synopsis of Perceived Health Conditions in eMUAs

Having established that people's perception of healthcare need is informed by their awareness, which in turn is context-sensitive, this section explicates components of perceived healthcare needs in the study area, which mediate care-seeking behaviours. These discussions are also congruent with the five main components of common-sense models of illness (Martin *et al.*, 2003, p. 206; Benyamini, 2013, p. 284; Sarafino *et al.*, 2015, p. 232), which effectively corroborate Phase I of the 'three-delays model' adopted for analyzing perceived accessibility in this study. The main components of common-sense models of illness are: (1) illness identity (or symptom labels), (2) causal attribution (and underlying pathology), (3) perceived consequences (or severity), (4) temporal expectations (or prognosis ideas or timeline), (5) curability (or controllability or symptom management ideas) (Martin *et al.*, 2003, p. 206; Benyamini, 2013, p. 284; Sarafino *et al.*, 2015, p. 232). Based on empirical primary data of perceived healthcare needs in the study area, Appendix B.1 explicates facets (1) and (3), after which facets (2) and (4) are detailed in Appendix B.2. The remainder of this section synthesizes the key findings thereof.

Psychosocial theories of health are helpful in understanding and explaining perceptions of healthcare needs and their associated care-seeking behaviour. People's subjective understanding of symptoms, illnesses, diseases, medical conditions and health threats constitute their illness perceptions, all of which are context-sensitive, as illustrated in Figure 7-2 (Benyamini, 2013, p. 281). These **cognitive representations** or **common-sense models of illness** are constructed from lay ideas and expectations about illness, which may or may not be correct (Sarafino *et al.*, 2015). People's direct experience and other sources of information, such as their social networks, education, or culture inform their common-sense models, all of which are both contextual and personal, as suggested by Figure 7-2.

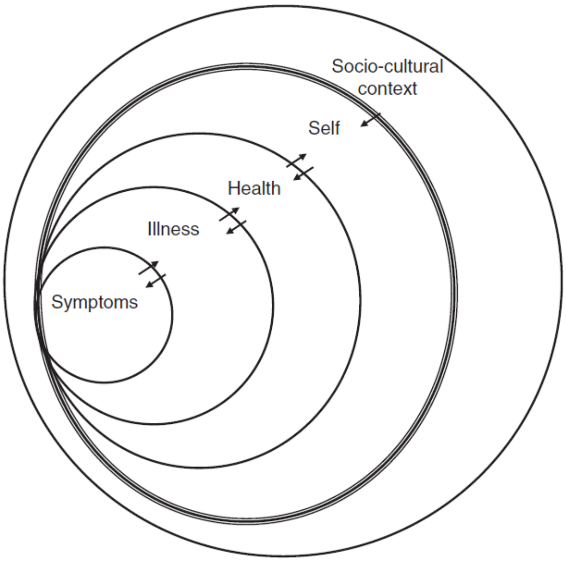

Figure 7-2 A schematic presentation of the associations between widening circles of illness and health perceptions and the way in which they are embedded in the self-system and the sociocultural system (Benyamini, 2013, p. 282).

This implies that the same illness type may be given different cognitive representations in each of the senatorial districts in the study area, which serve as the distinctive socio-cultural units of analysis for the current chapter. Furthermore, within each socio-cultural unit, the same illness type many be ascribed a different treatment-related behaviour based on an individual's socio-demographic characteristics as informed by their socioeconomic status, education and social network. This thesis is concerned with place/group-based analysis of perceived need and access; thus, while pertinent, individual perceptions are outside the scope of the current study (Litaker *et al.*, 2005). Friends, relatives, or co-workers constitute a **lay referral network** (i.e. a social network) of non-experts who interpret a patient's symptoms and provide advice before a patient reaches a decision to seek medical attention (Martin *et al.*, 2003, p. 215). Although social media and mobile communication networks have disrupted the geography of such lay referral networks (for localities with high internet penetrations and telecommunication networks), a person's lay referral network is likely to be most informed by their local context. Therefore, people in the same locality (who may share similar culture and/or belong in the same socioeconomic status) are likely to receive the same lay advice and therefore exhibit similar reactions to the same illness symptoms. This means that lay interpretations of symptoms would vary for different localities. This, in turn, stimulates a variety of health-seeking behaviour. Furthermore, localities comprising people of high socioeconomic status are likely to belong in lay referral networks that provide good advice. This is because these localities are likely to have networks of people who are more educated and, therefore, more health literate than disadvantaged localities, which are likely to be less educated. Indeed, people of high socioeconomic status tend to have people of various professions in their informal social networks, including medical doctors. Therefore, unlike deprived localities, people in affluent localities may be able to receive expert medical advice from their lay referral network. Hence, the effect of a lack of social capital by people of low socioeconomic status in rural contexts is underscored (Stephens, 2008; Cockerham, 2014b; Coll-Planas *et al.*, 2017; Musinguzi *et al.*, 2017; Paccoud *et al.*, 2020).

In short, common sense models of illness are informed by personal experiences as well as lay referral networks, and in turn, determine people's health awareness and the health-seeking behaviour that ensues. This study therefore supports a recent argument for the inclusion of **awareness** as one of the core dimensions of healthcare access (Saurman, 2016). However, further to Saurman (2016), this study considers awareness to also be implicated by the notion of perceived need. Encapsulated in the awareness dimension of access is the concept of **health literacy**. Patients (and healthcare providers) are empowered to the extent that they can access, understand, and use information to make health decisions (i.e. health literacy). Consequently, not only do people in eMUA have very poor accessibility to healthcare services, but they are also disempowered by virtue of their low healthcare awareness (and poor health literacy). In Nigeria, these are typical attributes of remote rural communities, owing to their poor socioeconomic status and social exclusion. The nature and level of health awareness are also different for various contexts, and this, in turn, mediates people's perceptions of both need and accessibility. Perceptions of healthcare accessibility is therefore the theme of the next section.

7.3 Manifestations of Poor Healthcare Accessibility

Experientially, the poor accessibility of healthcare in the study area is explained in any or a combination of the indicators discussed in this section. In this regard, poor accessibility is determined/explained by the presence and severity of multiple structural barriers to healthcare, based on respondents' narratives. Various indicators of access from both qualitative and quantitative perspectives are well-documented in relevant literature (Grimes *et al.*, 2011; Jacobs *et al.*, 2012; Kyei-Nimakoh *et al.*, 2017; Geleto *et al.*, 2018). In the context of the current study, the three-delays model is used to weave experiential barriers of access together (Thaddeus and Maine, 1994). This is because it is a relatively simple framework which not only allows simultaneous consideration of quantitative and qualitative aspects, but has also been utilized in several studies on healthcare access (Sorensen *et al.*, 2011; Combs Thorsen *et al.*, 2012; Mgawadere *et al.*, 2017; Geleto *et al.*, 2018). The three-delays model proposes three aspects of delays in patients' quest to obtain care, as illustrated in Figure 7-1. These are: (1) delay at home or at point of origin, (2) travel-related delays, (3) delays at a healthcare facility or point of care provision. In explicating relevant accessibility aspects that may not be well-considered by the three-delays model, other conceptual models, especially Levesque *et al.* (2013) and Cabieses and Bird (2014) are complementary, both of which are also sensitive to subjective and objective perspectives.

7.3.1 Problems with Proximal Healthcare Facilities

In rural villages[77] in Nigeria, existing public facilities/amenities (like boreholes, schools or clinics) are usually reachable in about 15 minutes by trekking, which is the main transportation medium in these contexts. It is also expected that there are many neighbouring/adjacent communities, which are within 15 minutes (by commercial motorcycle) and these adjacencies should provide a variety of opportunities for effective healthcare outside a patient's immediate community. At the basic or most acute level is a total lack or non-functionality of healthcare facilities in a patients' community/village and neighbouring villages (Echoka *et al.*, 2013; Ganle *et al.*, 2014; Udeh *et al.*, 2014; Chi *et al.*, 2015). This is the dominant narrative in

[77] A village is hereby qualified as rural since some communities/localities within (or adjacent to) urban areas in Nigeria are very much villages, in which case they can be called urban villages. These are villages embedded in or adjacent to towns, which may also be referred to as urban slums.

most of the eMUAs visited. In the three-delays model, this is a Phase II delay that often necessitates long travels to healthcare facilities in other communities, as discussed further in Section 7.3.3. Aside from obviously dilapidated healthcare facilities in the study area, as shown in Figure 7-3; more perplexing are well-built healthcare facilities that have never or are currently not being put to use for a variety of reasons discussed later in this chapter. Examples of such facilities are shown in Figure 7-4 and Figure 7-7. Consequently, respondents believe that a mere presence of a building tagged as a clinic/hospital does not indicate the availability of healthcare services (Osubor *et al.*, 2005; Conrad *et al.*, 2012; Roro *et al.*, 2014) if such facilities are barely functional:

> *"That is the building over there [pointing at the dilapidated PHC facility in Figure 7-3]. Look at its awful state. It has fallen apart; which doctor would want to stay there in that state?... That is the only hospital[78] we have here, …is it in that building that has fallen apart that drugs will be kept?"* [Ugbabo]

Figure 7-3 The only PHC facility at Ugbabo, which is currently dilapidated and non-functional.

[78] The native languages in the study area do not differentiate between various types/sizes of healthcare facilities. Thus, all healthcare facilities are translated as hospitals.

Figure 7-4 Well-built primary healthcare facilities that are non-functional. The top building is at Oganenigu ward, while the bottom building is at Ike-Bunu, at Ayetoro-Kiri Ward.

However, wherever respondents concede that there are healthcare facilities within their reach, several complaints are tendered about such facilities. A lack of equipment and supplies as well as a lack or shortage of healthcare personnel, are frequent experiences in the eMUAs (Echoka *et al.*, 2013; Exavery *et al.*, 2014; Ganle *et al.*, 2014; Ng'anjo Phiri *et al.*, 2016). Whereas, matters of healthcare personnel are discussed in Section 7.3.4; scarce equipment includes pregnancy-related scanners, ambulances, and other tools for proper diagnosis. Needed supplies such as drugs and syringes are also often unavailable (Mkoka *et al.*, 2014a; Essendi *et al.*, 2015; Oguntunde *et al.*, 2015). Furthermore, there are serious problems with the hospital infrastructure. They often lack labs or facilities to perform relevant medical tests, as well as being deficient in beds and sanitary facilities like toilets (Anyait *et al.*, 2012; Wright *et al.*, 2017).

> "*no facilities to carry out tests on patients, even patients who are due to be admitted, can't be on admission because there are no hospital beds*." [Eba]

"The last time I went to the hospital, I was pressed, there was no toilet to use, I had to ran out to the nearest bush to relieve myself." [Uvete]

A lack of power supply, as well as potable water, are also major concerns of respondents (Nyango *et al.*, 2010; Essendi *et al.*, 2015; Oguntunde *et al.*, 2015; Sialubanje *et al.*, 2015). For instance, talking about the only clinic in their village (Uvete), one participant explained that "*the power supply has been disconnected and there is no water*". Not only do available health facilities have limited hours of operations (being closed at night) (Mubyazi *et al.*, 2010; Exavery *et al.*, 2014; Essendi *et al.*, 2015), they are also poorly maintained and untidy (Mwaniki *et al.*, 2002; Mahiti *et al.*, 2015) as suggested by the following narratives:

"at night, during pregnancy associated pains, whenever we visit the hospital, there are no nurses available to attend to us. In the end, we go back and deliver the baby at home. As mothers, this is very challenging for us here". "Most times at night, when there is an emergency and you go to the hospital, you won't meet anyone there, then you will have to come back home with your child."

"*Some hospitals, if you go there, you suffer Mosquito bite even more*." [Uvete]

"*Government hospitals are dirty too. The cleaners are not taking care of the hospital and in a situation like that, a patient who goes there with a sickness will end up adding more to his/her sickness…*" [Eba]

These problems of lack of equipment and supplies as well as poor quality of infrastructure, constitute Phase III delays in the 'three-delays model' since they often come into force at the healthcare facility.

Apparently, limited opening times and poor maintenance are not unconnected with manpower issues, which are discussed in Section 7.3.4. All of these problems work in synergy to cause both difficulties and dissatisfaction with proximal healthcare, thereby creating a need to visit distant places, typically urban areas, for care:

"getting treatment is also a problem…" "we do not receive proper treatment here; people have to go to the next village to receive treatment, especially when you need to receive injection…" "Our treatment here is not adequate and we do not have where we can go for surgery if needed in this community." [Ike-Bunu]

"No C-S [Caesarean Section] here at all, no maternal services at all, that is why we need government hospital" "if we have the health services here, we will not be thinking of transport fare to Kabba[79]*..."* [Aiyetoro-Kiri]

From the foregoing narratives, it is noteworthy that following the ineffectiveness and accompanying dissatisfaction with proximal healthcare facilities; when patients decide to journey elsewhere, they often bypass other substandard facilities in adjacent villages to get to the nearest urban centre (Akin and Hutchinson, 1999; Meade and Emch, 2010, p. 421; Federal Ministry of Health (FMoH), 2016, p. 88). These patients are often of the opinion that villages like theirs are unlikely to have a better quality of healthcare than theirs; therefore, there is no need to bother to give them a try. This is well captured in the FGD at Aloko, wherein a participant remarked that: *"At Iyale and Aluko*[80]*, there are not enough doctors or good medicines there, so we have to go all the way to Anyigba - especially for serious medical problems."*

Even though serious problems with the availability of healthcare were reported at all the eight (8) communities visited, it is apparent from the foregoing that there are variations in the nature/type and acuteness/severity of problems narrated. These variations are mediated by the nature of the local context, as discussed in Section 7.4. Furthermore, despite serious problems with the available options for care, patients are sometimes constrained to making use of available proximal options, even if they are ineffective and/or unsatisfactory, as discussed next.

7.3.2 Lack of Alternatives

Patients are sometimes constrained to using any available option even when it is neither satisfactory nor convenient. This is a typical case of a monopoly of the supply of healthcare-related goods and services. For instance, respondents lamented having to visit the only chemist available even though they do not trust both the quality and efficacy of prescribed drugs from there. Healthcare facilities that are known to provide substandard/unsatisfactory services are also patronized for lack of alternatives, especially during emergencies.

[79] Respondents would bypass about 3 to 4 not so urban communities before reaching Kabba town for healthcare, see Figure 6-1.

[80] Patients from Oganenigu-Aloko and Ugbabo would bypass health facilities at Iyale and Aluko (both of which are villages) before reaching Anyigba, which is a major urban centre in the study area. See Figure 6-1.

There is also a limited choice in the transportation mediums to use. For instance, in emergency health cases, there is almost no alternative to chartering a car at a usually exorbitant rate. Furthermore, at certain times of the day, there is no alternative to using '*okadas*' to travel long distances in order to obtain care. Clearly, these are undesirable predicaments of respondents, which are clear markers of their extreme inaccessibility to healthcare, more so that these transportation mediums and the duration of travel tend to add to extant health issues since they are usually very inconvenient. Despite sometimes patronizing proximal options, albeit reluctantly, patients would have no choice but to seek out fairly standard facilities in far-away places, especially if proximal healthcare proves ineffective. There would be no motivation to continue patronizing a particular (proximal) healthcare facility if this does not result in timely improvement of the health condition of a patient.

7.3.3 Travel-Related Disincentives in Care Seeking

The foregoing subsections are the main reasons patients travel outside their localities for treatment. Care-seeking in distant places with relatively standard care facilities comes with several transport-related disincentives. Chief among them are transportation costs, which are usually exorbitant in secluded rural communities owing to a myriad of reasons, especially long travel distance and/or time (Jammeh *et al.*, 2011; Adewole *et al.*, 2012; Combs Thorsen *et al.*, 2012; Niyitegeka *et al.*, 2017). Roads linking remote rural communities to urban centres are usually in very bad shape, as shown in Figure 7-5. These roads often get worse in the rainy season, making them barely passable by all but the most rugged 4-by-4 vehicles (Kawuwa *et al.*, 2007; Jammeh *et al.*, 2011; Edmonds *et al.*, 2012; Story *et al.*, 2012; Wilson *et al.*, 2013). Seasonal effects of poor roads were highlighted by one participant at Aiyetoro-Kiri, who pointed out that *"during the rainy season, especially by August, your car [referring to the saloon car used by the researcher] cannot come here as you can see*".

In addition to poor roads in eMUAs, there are no readily available means of public transportation in these localities, such as Taxis, Hire cars or ambulances (Doctor *et al.*, 2012; Worku *et al.*, 2013; Adewemimo *et al.*, 2014; Soma-Pillay and Pattinson, 2016). Moreover, the availability of the usually meagre public transport varies by time of the day, being mostly available in the mornings and unavailable at night times.

> "*The cabs we use here can only take you to Kabba and will not want to return that same day because of passenger…*" [Aiyetoro-Kiri]

Indeed, not only is a lack of transport options a result of poor socioeconomic conditions in these places, commercial transporters are usually unwilling to ply rough roads, as implied by the statement: "*if the road is good many cars will be going and coming*" [Aiyetoro-Kiri]

Figure 7-5 Poor quality of road infrastructure leading to eMUAs. A and B are in Oganenigu ward, while C and D are in Ayetoro-Kiri ward.

Furthermore, wherever available, commercial transportation mediums in remote rural areas are usually very slow and unreliable. First, at the car parks, taxis do not get filled on time, without which they will not commence the journey. Unlike developed countries, commercial road transportation mediums in Nigeria do not operate according to a fixed timetable, but rather operate on a demand/cost-efficiency basis. Even though this makes it harder to make hospital visitation plans and meet medical appointments, it is usually the case that most primary healthcare services operate as walk-in services that do not require prior appointments. Second, because of the rough roads, it is mainly rickety vehicles that are willing to ply such routes; hence, not only are they usually slow, they are also very inconvenient and more prone to breaking down midway or having accidents.

> "*Because of the bad state of the road, the vehicle could not move fast, hence, the incident [post-partum death of a bleeding wife]*" [Aloko]

Against this backdrop, in order to embark on emergency transportation in search of healthcare, a taxi has to be chartered, especially if the patient is too weak (or pregnant in labour) to travel by '*okada*' or if the journey is too far to be undertaken by '*okada*'. Whereas a chartered car is not immune from breaking down or discomforts as a result of the bad roads, chartering a car also implies paying the individual cost of its passenger capacity for a to-and-fro journey.

> "*if someone is in labour and want to give birth and the car she is in develops a problem due to bad road, they have to go and get another vehicle in the nearest village to take her, and this process increases her mortality risk.*" [Aiyetoro-Kiri]
>
> *"if the person is very sick and the vehicle throws them up once, is that not a problem?"* [Aloko]
>
> *"…you will be forced to hire the car and you will have to pay for the standard expected number of total passengers of the car, which literally cost you more, which means ₦1300 times 6, and the same thing if you want the driver to bring you back*" [Aiyetoro-Kiri]

This illustrates that transportation costs to PHC facilities are usually very high and unaffordable in eMUAs, most of which are remote rural localities (Jammeh *et al.*, 2011; Echoka *et al.*, 2014; Liambila and Kuria, 2014). This is further compounded if a patient's health condition is perceived to be critical/severe, as detailed in Appendix B.1.

> "*sometimes bike cannot carry someone that is sick, somebody that is sick seriously may not be able to climb bike…*" [Aiyetoro-Kiri]
>
> "*if one should opt for motorcycle (bike), the rider will charge you nothing less than two thousand five hundred (₦2,500) and if the condition of the patient is very critical, they charge you more.*"

In sum, the main travel-related disincentives in the study area are: exorbitant transportation costs; very bad/rough road quality; the limited availability of transportation mediums which exhibit significant diurnal variations; long travel durations at slow speeds; inconvenient/uncomfortable mediums of travel, which are also a high risk since they are prone to accidents and other weather hazards. For instance, in addition to accidents, commercial motorcycles are prone to environmental hazards such as dusts, heat, smoke, and rain. Not only do these factors discourage and/or delay care-seeking, but they are also able to worsen the severity of ailments, thereby increasing negative outcomes like mortality.

> "*it is not easy to put a sick person on the bike and ride down to Anyigba; the sickness may get worse*". [Aloko]
>
> "*Yes. our people die on the road as they are being transported out because our roads are not good.*" [Ugbabo]

These transport-related problems are the main Phase II delays (of the three-delays model) experienced in eMUAs of the study area. However, there is an indication that, whereas the creation of high-quality roads will ameliorate many travel-related disincentives in eMUAs, it is not a sufficient intervention for remediating all the associated accessibility problems. For example, it may not guarantee the availability of transportation mediums all day long; nor would all associated environmental safety and risk factors be eradicated. Even with overcoming this or aside from it comes other limitations in obtaining care, most of which constitute Phase III delays (of the three-delays model). Chief among them are issues with healthcare personnel and cost or affordability of services that directly or indirectly constitute phase II and/or phase III delays. These are the subjects of discussion in the remainder of this section, starting with healthcare personnel issues in Section 7.3.4.

7.3.4 Healthcare Personnel

Similar to problems with healthcare facilities discussed in Section 7.3.1, the most acute and popular experiential indicator of the inaccessibility of healthcare is a lack or shortage of healthcare personnel in eMUAs (Ganle *et al.*, 2014; Chi *et al.*, 2015; Kumsa *et al.*, 2016). This means that healthcare facilities in a community/village (and neighbouring villages) either lack a commensurate number and/or quality of healthcare personnel. In terms of the quality of personnel, wherever available, respondents indicated a preponderance of low cadre healthcare personnel (like CHEWs or Midwives), non-specialty personnel or poorly trained ones (Radjou *et al.*, 2013; Ashraf *et al.*, 2015; Oguntunde *et al.*, 2015; Stal *et al.*, 2015). For instance, a respondent at Ike-Bunu remarked that *"what we have is just an auxiliary nurse, so people move from here to Lokoja for treatment".* This has many implications for service provision. The few available personnel would be overworked and this is a supply-side disincentive, well-known as 'job burnout' (Mkoka *et al.*, 2014b; Chi *et al.*, 2015; Xu *et al.*, 2020). Low cadre personnel do not have the expertise to handle many health conditions; therefore, they do not fill many gaps in healthcare service delivery system (Miller *et al.*, 2003; Ali *et al.*, 2006). Consequently, this results in either long waiting times before patients are attended to by the few high cadre personnel (like doctors) or a total inability to deliver needed healthcare service and thus create a need to seek care elsewhere (Combs Thorsen *et al.*, 2012; Wilson *et al.*, 2013; Niyitegeka *et al.*, 2017). There is also a tendency for some patients to be harmed by inappropriate treatment or misdiagnosis from incompetent personnel (Roy *et al.*, 2010; Radjou *et al.*, 2013). These personnel-related issues work in concert to make potential patients sceptical of available services. Not only does a lack of trust deter the continuity of healthcare patronage, but scepticism is also associated with higher mortality (Safran *et al.*, 2001; Lings *et al.*, 2003; Ricketts and Goldsmith, 2005).

On the one hand, public healthcare personnel (especially doctors) are not assigned to these eMUAs; on the other hand, even if they are posted/transferred to a healthcare facility in any of these eMUAs, disincentives of both the health facility and the local context often discourage such personnel, forcing them to neglect their duties and then find ways to relocate to preferred workplaces (Mkoka *et al.*, 2014b). Health facility disincentives, which are well-explained in Section 7.3.1, include: poor infrastructure (such as dilapidated or poorly maintained buildings), lack of equipment and labs for treating patients or conducting tests and diagnosis as well as lack of basic medical supplies, especially drugs and injections (Johnson *et al.*, 2011; Snow *et al.*, 2011). To buttress this effect, a respondent at Ochi remarked that *"It does not feel good working in a hospital where you do not have basic work needs such as drugs to function properly. It is discouraging."*

Disincentives at the local context are discussed extensively in Section 7.4; they typically revolve around a dire lack of basic social amenities in eMUAs, most of which are very rural and remote communities as explained by one of the discussants at Ochi[81]:

> "*doctors and nurses that work here complain that there are no good schools for their children to attend, there is equally no water, they have to use their cars and go a distance as far as Alloma to get water. So, they find it difficult to stay here; they often leave*". [Ochi]

Put otherwise, a respondent explained that *"some staff are transferred here, but they leave after spending just about three months. They complain that this place is a village and lack basic amenities such as regular electricity and water and the generator we used to have is no longer functional."* [Ochi]

Further to the service quality aspects considered above, the (quality and) resulting satisfaction with treatment administered is also dependent on the competence of staff manning healthcare facilities (Conrad *et al.*, 2012; Hagos *et al.*, 2014; Kaye *et al.*, 2014). Speaking about a need for proper verification of the professional qualification of healthcare personnel, one

[81] Ochi and Ofabo (both in Ogbonicha ward) have good roads and are much less rural and remote than the fieldwork sites at Oganenigu ward. Yet, healthcare personnel have these complaints and are unable to stay.

participant at Eba remarked that *"…the last time I was injected by a nurse in our government hospital here, my health condition worsened and it is God's intervention that has kept me alive till now, so government should employ qualified nurses…" [Eba].* Similar risk factors associated with poorly trained healthcare personnel are well-documented (Liambila and Kuria, 2014; Carnahan *et al.*, 2016; Wright *et al.*, 2017).

Furthermore, nurses have been accused of being very disrespectful and unempathetic in their treatment of patients, the notion of 'Disrespect and Abuse' (D&A) (Ganle *et al.*, 2014; Mkoka *et al.*, 2014b; Sialubanje *et al.*, 2015; Wright *et al.*, 2017). Recounting her ugly experience with nurses, one participant at Uvete remarked that:

> *"They don't care for us whenever we are in labour, they always complain and make a lot of noise, especially if we go there in the night, they will feel so bad that they are being disturbed. They won't attend to you until when your child is about coming… Even when the child is about to come, until you shout at them before they will attend to you, sometimes before they will come to you, you might have already been delivered of the baby on your own." [Uvete].* Similar accounts were narrated at Eba.

Among other things, being shown disrespect is a disincentive to subsequent service utilization (Blanchard and Lurie, 2004; Ricketts and Goldsmith, 2005, p. 227). Since matters of disrespect are considerable in rural areas and derive from the typical imbalance in power relations between providers and users of healthcare in these contexts (Bowser and Hill, 2010; Abuya *et al.*, 2015; Afulani and Moyer, 2019), it is not surprising that in LMICs, healthcare access has been defined as empowerment aimed at balancing power relations in healthcare settings (McIntyre *et al.*, 2009, p. 188). Although there is a return to matters of power relations in Section 7.4.3, it is ironical that where medical doctors who occupy the highest position of power in the field of healthcare provision are reported to have provided healthcare services, positive remarks were recorded. Speaking about the attitude of doctors towards patients at Eba, a participant noted that *"they [doctors] are trying their best, they are attending to patients properly, but there is not enough equipment there to carry out their jobs properly"*. This is partly unlike popular explanations of power relations, suggesting rather that low-cadre staff tend to suffer a sort of inferiority complex in the service provision hierarchy, which prompts them to exercise their power and control in an overtly overbearing manner to rural patients who are typically less powerful in the healthcare system (Bradley *et al.*, 2016, 2019). Apparently, most reports of disrespectful or harsh treatment of patients seem to have been recorded at Nagazi Ward, since at other localities, some positive feedback about personnel were recounted. For instance, at Ugbabo *"the nurses and other staff there treat us well"*. This may also be because, unlike other eMUAs that typically suffer Phase II delays, Nagazi ward exhibits Phase III delays all through.

These poor attitudes tend to be peculiar to public hospitals as one participant at Eba aptly noted: *"It was barely a week ago I visited a private hospital, the doctor attended to me nicely, even the nurses and I interacted very well, and I am very happy about it."*. A key reason for these disparities in the attitude of public and private healthcare providers is that public personnel are aware that their earnings/salary are not dependent on the patronage of patients or the quality and satisfaction of services rendered. This point is accentuated by a participant at Eba who remarked that "*government hospitals are fond of using abusive words on patients who are in serious pains, but in private hospitals, you won't find that because they need patients.*" Associated with attitudinal concerns of patients are sentiments or discrimination exhibited by personnel in the discharge of their duty (Bowser and Hill, 2010, p. 12). Talking about public health facilities, a participant at Eba remarked that:

> "*There is this issue of favouritism, nepotism and tribalism in our government hospitals. You can go to the hospital earlier than others, but the nurse or doctor in charge will attend to 'his/her person' before you, even if your health condition is more critical than theirs. This happens because the person who receives preferential treatment is a relative or of the same tribe/ethnic group as the healthcare personnel on duty*". [Eba]

Other forms of sharp practices or fraudulent activities have been reported of medical personnel, which impact negatively on accessibility (Mkoka *et al.*, 2014a, 2014b; Chi *et al.*, 2015). A conflict of interest which manifests as divided attention results from personnel who, despite working at a public health facility, also own/operate a private practice, the notion of 'dual practise' (Kiwanuka *et al.*, 2011; González and Cuadrado, 2019; Khim *et al.*, 2020). In the words of a participant at Ochi, "*Some of these doctors run their own private hospitals, so their attention is divided… so, they [referring to healthcare personnel] are nonchalant about the patronage the hospital gets*". Similar concerns were raised by participants at Aiyetoro-Kiri and Eba. This suggests that the problem of personnel availability is far more complicated than it appears on the surface.

Other fraudulent or sharp practices of healthcare personnel include: (1) commercializing drugs provided for free by the government or diverting public subsidized drugs to their private facilities for profit; (2) using their political connections to influence their redeployment to health facilities in favourable urban locations. The consequence of this type of redeployment is that there is a surplus of doctors in urban areas that already have a preponderance of private practitioners as a result of relatively favourable economic factors. Conversely, poorly staffed facilities in eMUAs are further disadvantaged in terms of personnel availability. These effects were narrated at both Ochi and Eba as follows:

> "*At government hospitals, drugs that should be given to us for free, are being hijacked by the nurses there, who sell them at their private chemists at home. They also direct us to patronize their private chemists.*" [Eba]
>
> "*Some personnel are willing to live and work wherever they are transferred, but others will insist on being redeployed because they know influential people in government who can help them influence the transfer. The result of this is that some places have more doctors than required, you see a hospital in places like Anyigba choked up with doctors and they end up not having any work to do; while here, we do not even have one*" [Ochi]

In sum, in terms of accessibility to healthcare personnel, patients expressed many concerns. Both the local context as well as their inherent healthcare facilities doubly disincentivize healthcare personnel in eMUAs (Darkwa *et al.*, 2015). This is the main cause of a lack or shortage of healthcare personnel in these contexts. Many public personnel also operate private practices, resulting in divided attention and a conflict of interest. On the one hand, this sometimes causes neglect of duty or absenteeism. On the other hand, this promotes some form of sharp practices or fraud, such as diverting subsidized medical supplies to their private practices, referring patients from public hospitals to their private practices and an unwillingness to be transferred away from localities wherein their private practice is established. Some senior medical personnel are therefore able to use their political influence to get themselves redeployed to preferred urban locations, to the disadvantage of service availability in eMUAs, which are typically remote rural localities. Low cadre medical personnel, especially in government hospitals, exhibit poor attitudes toward patients, which manifest as being disrespectful or harsh. They also are biased in the dispensation of their duties by granting priority medical attention to their ethnic or family affiliates, even if others deserve more urgent attention (Johnson *et al.*, 2011). In other words, they exhibit favouritism by eschewing the principle of 'first-come-first-served'. Finally, a major personnel demotivator which was mentioned in at least four (4) of the fieldwork sites[82] is the matter of staff salaries, which serve as a major driver of many of the undesirable personnel-related issues covered in this section, the most acute being strike actions (Johnson *et al.*, 2011). Put briefly, a participant at Ochi remarked that *"workers don't bother to show up because they are not being paid"*. This leads to a consideration of other financial disincentives of healthcare accessibility in the study area.

7.3.5 Cost and Affordability

The financial costs incurred by people in eMUAs in obtaining healthcare services and drugs tend to be higher than what is spent by people in other contexts (Worku *et al.*, 2013; Liambila and Kuria, 2014; Kumsa *et al.*, 2016; Wright *et al.*, 2017), because eMUAs are often remote rural places. From the perspective of accessibility, this is problematic because patients who are unable to afford this cost are deterred from seeking care and/or delayed from obtaining it. It is often the case that these patients resort to treatments with TCAM options or chemists, only to revert to western medicine when this might have proven unsuccessful and by which time their health condition would have become more severe (Mkoka *et al.*, 2014b). This has adverse effects on health outcomes in the study area. For instance:

> *"there was once a pregnant lady whom I asked to go for a scan. She replied that if she had money to do this scan at Kabba, she would rather buy baby materials. …to cut a long story short, when she eventually wanted to deliver, she lost the baby. So, if we have the health services here, we will not be thinking of transport fees to Kabba"* [Aiyetoro-Kiri].
>
> *"Myself as an example, when I was sick, I took herbs, but when the sickness did not subside, I went to the hospital where they gave me about eight injections before I got better, I spent about four thousand six hundred naira on the sickness (₦4,600)"* [Ike-Bunu]

Not only are drugs less available and more expensive in eMUAs; where available, chemists stock up less effective drugs that can be afforded by the local community at a good profit margin. Even if high-quality drugs are available at eMUAs, patients are likely to purchase

[82] This is a matter at all fieldwork sites in Ogbonicha and Nagazi Wards. Unlike the other wards whose accessibility challenge are very acute, embodying both availability and travel-related disincentives; in these wards, the main difficulty is poor availability. In other words, sketchy services are provided which form their basis for narrating personnel-related issues.

cheaper and less effective drugs because of the typically high cost of drugs in these places. The following remarks adequately capture various ramifications of drug-related costs associated with healthcare accessibility in eMUAs.

> *"the cost of drugs here is too expensive sometimes and we cannot afford to pay for it, this makes people go for cheap drugs which are less or not effective"*. *"They [referring to chemists] buy all these little and less expensive drugs in order to profit because the costly ones will not be patronized and not earn them profit."* *"…some drugs they give us here are more costly than other places or in the hospital, sometimes they ask us to go to Kabba and get it, of which we spend up to ₦10,000 for transport and other things."* [Aiyetoro-Kiri]

On the other hand, the more conducive business geographies of urban contexts mean that high-quality drugs are likely to be available since there is the likelihood for adequate demand from people who can afford to purchase them before their expiry dates, unlike in remote rural localities. Furthermore, not only is it cheaper to stock up and run pharmacies in urban contexts (because of economies of scale)[83], competition from multiple pharmacies helps to keep the prices of drugs in check, unlike in eMUAs.

It can therefore be seen that the high financial cost of healthcare services incurred in eMUAs typically results from the aggregate cost of treatment, transportation and drugs. In section 7.3.3, transport-related costs are considered in which the various reasons for the high transportation cost in eMUAs are explained. This includes a need to charter a taxi or use a commercial motorcycle to travel long distances on very bad roads. Financial problems in eMUAs are compounded by a situation whereby patients start by patronizing substandard proximal options before seeking care at distant places when those proximal options prove ineffective (Mkoka *et al.*, 2014b; Nwameme *et al.*, 2014). In this regard, a respondent at Aiyetoro-Kiri remarked that *"after paying about ₦6,000*[84] *at their clinic, they sometimes discover that the sickness is still there. Consequently, they still have to go to Kabba, thereby spending double to treat the same sickness"*.

[83] Because of the hot tropical climate of Nigeria, pharmacies need regular electricity for refrigeration and air conditioning to keep drugs at their recommended storage temperature. Although there is not steady power supply in urban areas, the erratic supply is much better than the total disconnection from the power grid in the rural areas visited.

[84] Recall from Table 3-13 that about 56% of the participants in eMUAs earn less than ₦25,000 per month. The current minimum wage in Nigeria is ₦30,000, which is not a living wage.

Typically, people in remote rural localities in Nigeria are of low socioeconomic status. This implies that they suffer more financial limitations than the general population. Therefore, the effects of these high financial costs of obtaining healthcare in eMUAs are very telling. Aside from refusal or delays in obtaining care, affordability also greatly informs aspects of patients' preferences. For instance, although private facilities were sometimes perceived as providing better quality services, participants in eMUAs prefer that good government health facilities be sited in their localities because they are more affordable. Their preference for government hospitals was expressed in these words:

> "*we prefer government facilities because private ones are more costly*" [Aiyetoro-Kiri]
>
> "*I prefer government hospitals because it's affordable*" "*Treatment [in government hospitals] is more affordable and cheaper than private hospitals. They may bill a patient up to ₦8,000 to ₦10,000; but when you don't have up to such amount, treatment depends on what you have or can afford at the moment*". [Eba]

Other dimensions of cost include the indirect cost associated with seeking care in faraway places from home as well as missed opportunity to save some money or engage in one's occupation, opportunity-costs. These indirect costs include accommodation and feeding costs for care-givers who accompany a sick person to the hospital (Lewallen and Courtright, 2002; Posse *et al.*, 2008). In this regard, the father of an accident victim at Aloko remarked that:

> "*I had to feed everyone that stayed with him [the patient] at the hospital before he got better. The ₦220,000 I spent covered just the medical bill. If there was a hospital here, I probably would have just been required to pay only medical bills and sort out the feeding, I definitely would not have needed to spend on feeding separately.*"

Although there is an overwhelming preference for western medical services over TCAM approaches in the study area (as discussed in Appendix B.2), a major reason for the patronage of TCAM services in eMUAs is the unaffordability of western medicine (Ejembi *et al.*, 2004; Osubor *et al.*, 2005; Lakew *et al.*, 2015). For instance, when asked why patients, especially pregnant women, tend to prefer prayer houses to patronizing a hospital, the response was unanimous as follows:

> "*It is a lack of money". "The problem is money". "If there is money, husbands will encourage their wives to go to the hospital during pregnancy. …money is not required to visit the prayer house". "…do they transfuse blood in a prayer house? (laughs), can a*

pastor act as the mid-wife? It is just poverty. They make a resolve that God should just handle everything." [Ochi]

"*Sometimes, the lack of money is the reason why people go to traditionalists or prayer houses for treatment or prayers because they can't afford western hospital expenses.*" [Eba]

"When I was diagnosed with typhoid, I could not go to the hospital, so I used herbs…" [Ike-Bunu]

Being that rural communities are typically socioeconomically disadvantaged in Nigeria, the cost of western healthcare services is a significant barrier to PHC utilization (Kyei-Nimakoh *et al.*, 2017). Having considered the main experiential dimensions of accessibility in eMUAs, Section 7.4 discusses the effects of the local context, after which remedial perspectives of participants are covered in Appendix B.3. Before these, the next section briefly summarizes the discursive indicators of accessibility elicited from the current study.

7.3.6 Summary of Experiential Indicators of Accessibility

Good health facilities are unavailable or in short availability in eMUAs because public officials have refused to provide them and/or failed to create an enabling local context for both private and public healthcare facilities to thrive. At the same time, healthcare personnel are unwilling to work in eMUAs because of their lack of basic amenities since they are very rural and remote. Whenever public healthcare personnel are deployed to these contexts, they are able to use their political influence to redeploy themselves to more conducive localities, especially urban areas. Not only does this exacerbates the problem of poor accessibility in eMUAs, but it also promotes rural-urban inequalities of healthcare accessibility in the study area. Overall, the dire lack of good healthcare facilities and personnel in eMUAs is a result of complicated governance and political mechanisms which work in synergy, as discussed briefly in Section 7.4. An extensive analysis of these mechanisms is a matter for further research outside the scope of the current study. For economic reasons, private providers do not consider eMUAs as viable business locations for siting good healthcare facilities or pharmacies. The few small facilities and pharmacies in eMUAs are not only usually substandard, but also have high service or drug prices. This is compounded by the fact that people in eMUAs are not well-off and therefore cannot afford the relatively high cost of quality medical care.

7.4 Contextual Effects: Sociocultural and Topographic Aspects

This section considers two facets of contextual effects. The first is the physical environment, which relates to the lay of the topography relative to the spatial organization of the study area's settlements as well as the local social amenities available. The second is the sociocultural context, which has been shown in Section 3.4.1 to comprise three distinctive categories in the study area. These are synonymous with the senatorial districts, which formed the basis for designing the methods of primary data collection for the current chapter.

In attempting to make sense of the reciprocal effect of place/context on peoples' experiences of accessibility, the various fieldwork sites are categorized in two ways: (1) According to ethno-cultural distinctions, into Kogi Central (Ebira), Kogi East (Igala) and Kogi West (Okun/Kabba) and (2) According to the physical geography of the study area. Physical accessibility necessitates a consideration of the spatial organization of society, especially the relationship between settlement patterns (including population size and density) and the topography of various study contexts, especially the spatiality of healthcare facilities and services as well as transportation infrastructure. Furthermore, the presence and spatial organization of basic social amenities are of critical importance. For instance, there is a dichotomy in the quality/condition of available transportation infrastructure (i.e. roads and mediums of transport) in the field sites. Some wards have extremely bad roads (especially Aiyetoro-Kiri and Oganenigu), while others have fairly good roads (such Nagazi Farm Centre and Ogbonicha). There are also geographies to basic social amenities in the field sites, which were found to markedly inform contextual differences in participants' perspectives.

These make it possible to tease out influences that are either as a result of sociocultural variations or that are induced by the physical morphology and geography of various contexts/localities. While the foregoing categorization assumes that socioeconomic characteristics (such as income and education) vary by the ethno-cultural distinctions (i.e. categorization 1 above), this may not be the case in reality. Therefore, it is also possible to categorize the various study contexts based on socio-economic characteristics to understand their related contextual effects on healthcare accessibility. However, the sampling design for the focus group discussions did not factor socioeconomic variations, assuming rather that most participants belong in the same socioeconomic group, rural dwellers of low socioeconomic status, as suggested in Section 3.4.3.

7.4.1 Settlement Patterns and Social Amenities

This section attempts a brief explication of the effects of settlement pattern and topography (i.e. morphology) as well as local social amenities on the foregoing perceptions/experiences of healthcare needs and accessibility in eMUAs across the three senatorial districts in the study area. This is based on the researcher's observation documented in field notes as well as some aspects of the group discussions. In Section 4.3, it is established that although Kogi East is almost twice the population of Kogi Central and Kogi West; Kogi Central has a population density that is about four times that of the other senatorial district (please see Table 4-4). Not only is this a result of the relatively very small land area of Kogi Central, but it was also observed that a large portion of the topography of Kogi central is very rocky and rugged, unlike the other senatorial districts. This topography therefore constricts the population of Kogi Central in very dense settlements, which facilitates the provision of public amenities as well as incentivizing private service providers (or businesses) (Humphreys and Smith, 2009, p. 74; Burkey, 2012, p. 793). Consequently, not only are there few very rural communities in Kogi Central, these rural communities are not really remote, since the overall land area of the same district is only about 3,150 km^{2,} which is also very compact. In Section 3.3.1.3, it is well-established that with small compact areas comes better accessibility. Therefore, although Kogi Central does not have as much availability of PHC facilities, personnel and services as Kogi West (as shown in Figure 6-9 and Figure 6-10); it has the best spatial accessibility to most PHC services in the study area (as shown in Figure 6-18).

Whereas the ruggedness of the local topography tends to have created some accessibility-related advantages for PHC accessibility in Kogi Central, the same cannot be said of the other two senatorial districts of the study area. In these districts, it was observed that the topography of the unpaved sections of roads connecting eMUAs to their closest towns were not only long, but also very rugged. Consequently, although communities that suffer dire access-related disadvantages may be on plains, their interconnecting routes transverse very rugged terrains, as shown in Figure 7-6 below. Deleterious effects of poor topography on healthcare access are well-known (Wilson *et al.*, 2013; Myers *et al.*, 2015; Alam *et al.*, 2016); however, it can be seen that because of the spatial relationship between settlement patterns and topography, a difficult terrain could stimulate some positive PHC accessibility in some localities (such as Kogi Central). Since other aspects of these travel-related disincentives regarding the poor quality of roads linking eMUAs are discussed in Section 7.3.3, it suffices to say that in addition to the lack of political agency in these eMUAs, the difficulty and expense of constructing roads on rugged terrain is likely to serve as a demotivator for relevant public authorities. Furthermore, the rugged relief of these terrains means that not only will road construction costs be very high, maintaining these roads would also be difficult since they are more prone to erosion. Further discussions of road quality are featured in Section B.3 wherein the desired remedial interventions of research participants are considered.

In addition to a lack of good roads, which in itself is a basic social amenity, eMUAs most of which are remote rural localities, lack other basic social amenities (Essendi *et al.*, 2015; Onnis and Pryce, 2016). These include: mobile communication networks, potable water, electricity, as well as primary and secondary schools. Speaking about the effects of a lack of mobile telecoms services on PHC accessibility in eMUAs (Myers *et al.*, 2015), respondents remarked that:

> *"And if we have to phone Kabba, we have to go to a strategic position (location) to call. So, the road and GSM network is one of the major problems in this community." "I*

Figure 7-6 Road sections showing the rugosity of the terrain in eMUAs in the study area. A and B are in Ayetoro Ward (of Kogi West), whereas C and D are in Oganenigu Ward (of Kogi East).

believe when we have it [i.e. a PHC facility], no doctor will run away from here. The only thing that can send them away is mobile (GSM) network problem, but thank God, Glo network is better here now and when you go to 'Ike-Bunu' where you are coming from, they have MTN network there, but here, the network is not everywhere." [Aiyetoro-Kiri]

"We don't have network coverage as well" "They [referring to healthcare personnel] even complain that we don't have network coverage and good roads and they cannot come and live in a place without these basic amenities, that is why we don't have a D.A.[85] till date." [Aloko]

Similarly, speaking about the deterring effect of the lack of potable water and good schools on the retention of healthcare personnel in eMUAs, respondents explained that:

"First, doctors and nurses that work here complain that there are no good schools for their children to attend, there is equally no water, they have to use their cars and go a distance as far as Alloma to get water. So, they find it difficult to stay here; they often leave. It is one of the challenges we face here." "Yes, we believe that if they [healthcare personnel] have access to water, they will stay. Many of them have personally told me that." "...Most of them are not Igala. If there are good schools here, they will stay." [Ochi]

In blaming their poor PHC accessibility on a lack of electricity and other social amenities (Essendi *et al.*, 2015), respondents remarked that:

"we need network providers to help us here and electricity; there must be electricity for the hospital to function well." [Aiyetoro-Kiri]

"I am the admin officer there [referring to the non-functional hospital in their community, see Figure 7-7] ...Some staff are transferred here, but they leave after spending just about three months. They complain that this place is a village and lacks the basic amenities such as regular electricity and water and the generator we used to have is no longer functional. The last doctor posted here who left sometime last year had the same complaint…" [Ochi]

Further to these narratives, the researcher observed that in addition to the dearth of basic amenities explained by research participants, other social amenities that could be of relevance

[85] D.A. means Dispensary Assistant. These are like Community Health Extension Workers (CHEW).

to maintaining the modern lifestyle of senior medical personnel like doctors are unavailable in eMUAs. These include: banks, post offices, police stations, restaurants, hotels/guest houses, boutiques, auto technicians, bars, superstores, filling stations as well as servicemen skilled at providing specialist services for a modern lifestyle. For example, if the car of a healthcare professional breaks down and/or needs servicing, s/he is unlikely to find competent auto-mechanics in eMUAs. This means that healthcare personnel could become stranded either at home or while commuting, especially in places where there are no mobile communication networks. Furthermore, the cost of repairing damaged cars, as with obtaining other services, would be relatively higher in eMUAs since this would usually entail transporting servicemen from adjacent towns, which are usually distant. This underscores the salience of transportation and mobile communication infrastructure in ameliorating access-related disincentives in eMUAs as discussed further in Appendix B.3.

On the one hand, the narratives and observations of this section suggest that the discouraging effects of a lack of basic social amenities on the availability of PHC services in eMUAs are mainly a problem of remote rural communities in Kogi East and Kogi West[86]. The reasons for these are that Kogi Central has a relatively small and compact landmass, as explained at the beginning of this section; therefore, unlike the other districts, there are no remote communities in Kogi Central. Indeed, since eMUAs in the same senatorial district have relatively better access roads to adjacent towns, which are not very far away (being about 20 minutes by car), it is very possible for healthcare personnel to reside in such towns (like Okene) while commuting to work at rural healthcare facilities (in Nagazi Ward). On the other hand, the disincentivizing effect that a lack of social amenities has on the ability of eMUAs to retain healthcare personnel seems to be very apparent at Ogbonicha-Ochi. This is because despite being a remote rural community, Ochi has good access roads to distant neighbouring towns (like Anyigba) as well as a big, well-built hospital which, though, is currently non-functional (as shown in Figure 7-7), used to be functional in the recent past. This hospital was built circa the year 2001 and fully operationalized when an indigene of Ochi-Ogbonicha was the governor of Kogi state, Late Prince Abubakar Audu[87]. The same governor also ensured that other complementary social amenities like good primary and secondary schools as well as potable

[86] Ochi and Aloko are in Kogi East, whereas Aiyetoro-Kiri is in Kogi West.

[87] https://en.wikipedia.org/wiki/Abubakar_Audu (Accessed on 12th May, 2020)

water (from boreholes) were available to encourage healthcare personnel to reside in the same village.

The administrative tenure of Prince Abubakar Audu was truncated by 2003, after which the hospital continued to witness rapid decline in service provision such that by 2013, it had become barely functional[88] , and it is now non-functional (as of March 2019). Not only does this illustrate the effects of political personality and patronage on PHC provision in the study area, but the adverse effects of unstable political transitions on public service provision in the country are also foregrounded (Cabieses and Bird, 2014). This also underscores the salience of the analytical approach employed in the current study (especially in Chapter 6), in that the mere presence of a health facility is not synonymous with health service provision, no matter how big or well-built such facilities may be (see also Section 7.3.1).

Figure 7-7 A big hospital at Ochi-Ogbonicha that is currently dilapidated and non-functional. (A) Oblique view of hospital's main entrance showing a broken-down ambulance (B) Hospital passage to other units, showing staff quarters, (C) Some staff quarters (D) Access road of hospital showing its signboard and fieldworkers.

[88] See https://www.facebook.com/ObakaEntertainment/posts/the-executive-governor-of-kogi-stategovernors-officelugard-houselokoja-kogidear-/510120732377827/ (accessed 12th May, 2020)

7.4.2 Sociocultural Aspects

Sociocultural factors have been shown to greatly inform the common-sense models of health conditions discussed in Section 7.2 (and Appendixes B.1 and B.2). In this regard, as the sociocultural context of a patient varies, the same type of health condition may be ascribed to different causes as well as curability options. Whereas sociocultural variations would always manifest with regards to curability options, in the case of causal attribution, they are likely to be more apparent for health conditions that are associated with diabolic/spiritual causality. By the same token, variations in sociocultural context exert the strongest influences on sociocultural aspects of perceived accessibility, especially experiential indicators of Phase I and III delays (Myers *et al.*, 2015; Geleto *et al.*, 2018). In addition to complicating the perceptions of need, the effects of sociocultural contexts are strong on the acceptability facets of healthcare access, which are also mediated by both Phase I and III delays (Grimes *et al.*, 2011; Levesque *et al.*, 2013; Kyei-Nimakoh *et al.*, 2017; Bright and Kuper, 2018).

7.4.3 Synthesis of Contextual Effects

In my final analysis, I argue (and demonstrate) that while the sociocultural categorizations used in choosing field sites are relevant to distinctions associated with treatment options based on varying perceptions about the aetiology of various medical conditions, it is the physical characteristics of a local context (in terms of socioeconomic amenities) that provides the greatest basis for spatial distinctions regarding perceived PHC accessibility in the study area. In this regard, the quality of locally available transportation infrastructure is the single most important differentiator. Unlike hospitals, the provision of proper transportation infrastructure is almost exclusively a matter of public provision, apart from commercial transportation mediums like motorcycles and taxis. It can therefore be suggested that a lack of quality road infrastructure in eMUAs is sustained by their dearth of influential local political representatives at relevant levels of government (especially the state and federal government), which are usually responsible for road constructions. Some respondents support this assertion when they bemoan their lack of influence in government in the following words:

> *"Sir, if the government wants to intervene as it relates to hospital and education. They can first start by helping us with water, hospital needs like drugs and staff; it will ease off for us. If only we have someone to help us cry to the government of today on this".*
> [Ochi]

This suggests that unlike perceptions of abstract (i.e. aspatial) phenomena like acceptability or satisfaction, perceptions of spatial accessibility are more likely to covary with other underlying physical phenomena (such as quantitative facets of social exclusion), save the extent to which there are correlations between spatial and aspatial aspects. Thus, participants' **common-sense models of illness representation** tend to vary by the dominant sociocultural markers in the study area. However, this cannot be said of the strictly physical aspects of spatial accessibility, which tend to vary by other largely physical contextual factors of various localities. This suggests that the design of qualitative data collection for spatially sensitive dimensions of access should be customized based on the aspects of the access conundrum (i.e. physical or abstract/cultural) that are being studied.

Apparently, matters of potential accessibility are much less a result of micro contextual socio-cultural factors than they are determined by macroscale political-economic factors and governance (Litaker *et al.*, 2005). This is particularly so for facets of potential spatial access, herein referred to as spatial accessibility. There are indications that contextual (i.e. microscale) differences in spatial accessibility are direct results of remoteness and rurality (White *et al.*, 2012). The disincentives created by these two forces are, in turn, sustained by macroscale developmental effects, especially the unsustainable political economy and governance structures in the country[89] (Cabieses and Bird, 2014). In other words, proximal drivers of poor spatial accessibility in eMUAs of the study area are rurality and remoteness, while distal causes are the macro-scale political economy and governance structures that ensure that these eMUAs are trapped in their perpetual state of underdevelopment. It follows that micro-scale variations in the intensity of negative effects of rurality determine differences in spatial accessibility of healthcare at various localities. Indeed, based on the inverse-care law, objective aspects of healthcare need (i.e. quantitative estimates discussed in Chapter 5 and part of Chapter 6) are also influenced by these macroscale political-economic factors. It can therefore be seen that political-economic factors exert an overwhelming influence on health; first, by creating disparities in objective need, second by creating disincentivizing contextual factors for spatial accessibility. Furthermore, the infrastructure of healthcare facilities within eMUAs are substandard and lacking in relevant equipment and supplies, thereby discouraging the retention of healthcare personnel in such facilities. This is congruent with the conceptual

[89] In Chapter 4, using automated zone designs, I explicate how inequities in administrative structures are entrenched in Nigeria, and perpetuate most other forms of disparities in the country.

framework of Onnis (2019, p. 27). Consequently, it is not surprising that the current poor accessibility in eMUAs has endured and tends to be worsening in recent times. The challenge then becomes a matter of counteracting these negative macroscale effects as a means of sustainably enhancing the spatial accessibility of primary healthcare services at eMUAs in the study area.

On the other hand, many nonphysical facets of accessibility are more affected by contextual sociocultural factors (Litaker *et al.*, 2005). They particularly exert some influence on perceptions of need and the health-seeking behaviour that ensues. Experiential aspects of care availability (such as attitudes of medical providers) and types of medical services patronized are also informed by contextual sociocultural factors. For instance, the power relationship between medical personnel and service users portrays a power hierarchy that is overbearing in remote rural areas because it is almost always the case that medical personnel have much higher social status than their patients. This is less likely to be the case with patient-personnel power relations in urban areas because unlike rural localities, people of high social status would patronize hospitals in urban centres. Consequently, this typically lopsided power hierarchy of healthcare utilization in rural areas is a veritable social structure (i.e. the field) for the exercise of 'symbolic violence' by healthcare personnel in these contexts (Jenkins, 1992; Bourdieu, 2000, p. 170; Weininger, 2002). In Nigeria, people in rural communities are not only of low social status but also tend to have limited (or no) alternatives for obtaining needed care, as discussed in Section 7.3. Thus, not only are they vulnerable to domination and mistreatment by medical personnel, they are also complicit by their subconscious subordination in deference to extant class hierarchies. At the same time, patients are cowed by and subservient to healthcare personnel because of their awareness of potential adverse consequences of challenging unpleasant power relations at healthcare facilities – a withdrawal of the already modest, inadequate attention they are used to receiving. Whereas elaborate considerations of the drivers and consequences of Disrespect and Abuse (D&A) abound elsewhere (Bowser and Hill, 2010; Bradley *et al.*, 2016, 2019), Appendix B.3 considers desired remedial interventions of the research participants as a basis for making inclusive policy-relevant recommendations in Chapter 8.

7.5 Summary and Conclusion

The primary purpose of this chapter is to corroborate and validate select aspects of the spatial analysis of PHC accessibility in Chapter 6. In so doing, it extends the findings of the current study by infusing relevant humanistic and social aspects (Kearns and Collins, 2010; Andrews and Crooks, 2012, p. 31; Johnston and Sidaway, 2016c). This is in tandem with egalitarian principles of distributive justice discussed in Section 2.2.2.2 and the inclusivity/participation aspirations of both the PHC approach and the SDG framework discussed in Sections 2.2.3 (WHO/UNICEF, 1978; WHO, 1998a, 1998b). These moral and ethical tenets underscore the salience of the explanatory sequential mixed methods research design of this doctoral research project in which the current chapter is both the last and only qualitative aspect. In this chapter, perceived healthcare needs, which is the commencement factor in the conundrum of access-related matters is explained by four (4) main perceptual facets; namely: (1) the label and/or symptoms of a given health condition, (2) its severity, (3) its cause (4) its curability. The preponderant health conditions identified by the general population are malaria and typhoid fevers, whereas other conditions evade lay cognition and are generally described as 'sickness' or 'disease'. Not only does this suggest a need for improved accessibility and treatment of these recognized conditions, but it also highlights the need for more diagnostic facilities in the study area. There are apparent demographic aspects of identified health conditions. Females and children have particular healthcare needs, which often warrant visiting healthcare facilities for needed care. Sicknesses are known to be caused either by physical or spiritual factors (like evil spirits) (Westerlund, 2006; 2012, p. 444; Echoka *et al.*, 2014). With few exceptions, if affordable, respondents prefer western biomedical services for treating health conditions that are perceived to be of purely natural causes; whereas, a need for TCAM services is associated with conditions that are attributed to spiritual agents of which TCAM provides more acceptable treatment options (Dillip *et al.*, 2012; Abubakar *et al.*, 2013; Lakshmi *et al.*, 2014; Agu *et al.*, 2018; James *et al.*, 2018; Peltzer and Pengpid, 2018). Socio-culturally, the context mediates peoples' ability to perceive all of these cognitive aspects of health conditions, as well as the health-seeking behaviours that ensue. For instance, whereas a given illness may be ascribed to natural/physical causes in one context, it could be perceived as being spiritually caused in another context. By the same token, for the same condition, participants' preference for Western biomedical treatments or TCAM varies socio-culturally amongst the three sociocultural contexts of the study area.

Nevertheless, for cases ascribed to physical causes, there is an overwhelming preference for western biomedical treatment, whereas TCAM is sought for cases that are ascribed to spiritual/diabolic causes or which could not be cured by western biomedical treatments.

The ‘three-delays model’ (Thaddeus and Maine, 1994) is invaluable in analyzing experiential indicators of healthcare accessibility, especially because it incorporates other conceptual frameworks of access and factors subjective and objective facets in consonance with the axiology of the current research project. Whereas only cognitive representations of health conditions constitute the perceptual indicators/explanans of Phase I delays in accessibility that are factored in this chapter, others abound. Data on other sociocultural factors of Phase I delays (such as a patient’s decision-making process) are difficult to elicit using focus group discussions because they are of a personal/individual nature, whereas the current study is concerned with group or community accessibility. In essence, it can be seen that because of their intricate nature/characteristics, Phase I delays are most amenable to contextual sociocultural mediation, as summarized in Section 7.2 (with details in Appendices B.1 and B.2).

In the study area, the experiences of poor healthcare access manifest experientially in the following ways: (1) problematic proximal healthcare facilities with limited alternatives (i.e. monopoly); (2) acute travel-related impediments, (3) complex issues of Human Resources for Health (HRH), and (4) unaffordable healthcare services intersecting with multidimensional poverty. Even though these exert secondary effects on Phase I delays, they are mainly Phase II and III delays. An interplay of both physical and sociocultural contextual effects mediates the foregoing experiential *explanandum*; nevertheless, experiences under themes (1) and (2) tend to be most informed by physical/environmental influences, as explained in Section 7.4. For example, it is apparent that within the same study area, topography exerts both positive and negative influences on spatial accessibility depending on the peculiarities and spatial organization of various localities (O’Connell *et al.*, 2015, p. 10). The multiple and self-reinforcing manner in which these disincentives of healthcare accessibility operate is foregrounded. For instance, poor transportation infrastructure promotes road accidents and at the same time, impedes healthcare accessibility in eMUAs. A lack of potable water in rural contexts means that there would be a high incidence of typhoid and cholera in these contexts, which at the same time, frustrates healthcare personnel from residing in these contexts. The lack of basic social amenities in rural communities incapacitates extant healthcare facilities that would need electricity, potable water and telecommunication to function effectively. The same unavailable social amenities in eMUAs discourage healthcare personnel from residing in rural contexts and simultaneously demotivates them from working in the substandard healthcare facilities therein. This illustrates the direct and indirect negative consequences that the lack of social amenities exerts in eMUAs, as illustrated by Onnis (2019, p. 27). This underscores the need for multiprong intervention approaches which are context-specific and at the same time sensitive to the multiple drivers of inaccessibility which operate at various spatial scales (Labonté and Laverack, 2008; Rassekh and Segaren, 2009; Carey, 2014; Carey *et al.*, 2015b; Eslava-Schmalbach *et al.*, 2019). Respondents are desirous of various interventions that will sustainably ameliorate their difficulties in obtaining needed healthcare and have made relevant though limited recommendations in this regard in Appendix B.3. These form the basis for further discussions of the policy- and practice-relevant recommendations presented in the next and final chapter of this doctoral thesis, Chapter 8.

This chapter shows that the problems of healthcare access in eMUAs are more chronic than the quantitative analysis could have suggested. For instance, the qualitative analysis considers only transportation using '*okada*'. There was no way of fathoming the diurnal availability of such transport mediums as well as stark variations in transportation costs that may be associated with traversing the same road types (assuming the same transport speed), across various localities. For instance, not only is it impossible to get a transportation medium at certain times of the day, but respondents also have to pay double transportation costs in many eMUAs. This suggests that spatial accessibility would also vary greatly by time of the day, in addition to seasonal variations that are recurrent in the literature on spatial access (Kawuwa *et al.*, 2007; Essendi *et al.*, 2011; Jammeh *et al.*, 2011; Wilson *et al.*, 2013). A popular assumption of most modelling of spatial accessibility is that travel time alone is a realistic measure of travel impedance, especially if an appropriate distance-decay function is applied in characterizing potential spatial interactions amongst places (in this case, healthcare utilization). In this way, it is taken that the relationship between travel time and cost and, in turn, utilization, emulates the adopted distance-decay function in the same way (in this case, the Gaussian-distance decay function) in every context. This qualitative study shows that this may be an over-simplification since the same travel time may have very different travel costs and therefore various distance-decay effects (or commuting disincentive). Instead of using only travel time as the impedance criterion for the modelling of spatial accessibility, an impedance index that incorporates both travel time and cost measures (as well as other aspects of commuting disincentive like convenience) may be more realistic. The challenge now becomes how to efficiently measure/quantify these (abstract) aspects of commuting disincentive, not least because this will involve an attentiveness to every single origin-destination transport in the study area. Presumably, this may become counter-productive in quantitative modelling of spatial accessibility, because of the extent of recursive details that this would entail, more so that data for such measures are unlikely to exist from secondary sources and therefore would require extensive fieldwork if quantifiable. In effect, the models reach maximum useful complexity and no longer become (universal) models but too bespoke and context-dependent; they thereby become of limited applicability/transferability to other contexts and at other times/eras.

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Chapter 8. Summary and Conclusion

8.1 Summary of Research Project

Health is a fundamental social good, therefore public authorities are keen on ensuring that people in their jurisdiction enjoy primary healthcare. Healthcare access is an important socioeconomic concern because with improved accessibility comes better healthcare utilization, which is invaluable for maintaining and/or improving the health of a population (Barnett and Copeland, 2010; Grzybowski *et al.*, 2011; McLaren *et al.*, 2014). Good health is positively associated with a high quality of life as well as increased socioeconomic productivity. It is therefore not surprising that good health is one of the Sustainable Development Goals (SDG) and other development-related metrics, such as the Human Development Index (HDI). Variations in health and healthcare accessibility are also matters of social justice, such that an injustice is done to population subgroups that suffer systematic deprivation of primary healthcare (Gostin and Powers, 2006). There are well-documented problems of primary healthcare accessibility in Nigeria, which have become worse in recent times (Efe, 2013). Many of these problems are discussed in the situation analysis of official documents of health-related agencies of the country, especially the Federal Ministry of Health and the National Primary Healthcare Development Agency (Federal Ministry of Health (FMoH), 2016, 2018). In addition to the global concerns and topicality of healthcare access, the peculiarity of Nigeria is foregrounded in the current study, which employs a geographical approach that privileges spatial analytics while also considering relevant subjective perspectives of the study population.

The literature review chapter establishes the moral and ethical foundations of this doctoral research. In this way, this doctoral research is grounded in the egalitarian principle of distributive justice as well as the human right to health framework. Both of these philosophical bases underpin the UHC aspiration of the SDG, which is set forth as Target 8 of Goal 3. Not only do these principles necessitate the disaggregation of health data according to relevant socioeconomic dimensions, but they also emphasize a need to focus on vulnerable/disadvantaged population subgroups (WHO, 1998b; McGillivray *et al.*, 2011; Da Costa Leite Borges, 2016b, p. 153; Rahman and Wazed, 2018). Thus, in the last empirical chapter, the focus is on marginalized rural communities that typically comprise poor people in remote locations, which are considered extreme Medically Underserved Areas (eMUAs).

The traditional focus of research projects in healthcare accessibility is concepts, methods and applications (van Wee, 2016), therefore in addition to the ethical foundations of this study, other relevant concepts are explicated and disambiguated. These notions include: healthcare need, demand, and supply; access and accessibility of healthcare; as well as equality and equity of healthcare access. This is done with a view to clarifying their nominal definitions as well as their operational meanings for the current study (Abler *et al.*, 1971, p. 33). The interconnections amongst these concepts are also foregrounded by invoking relevant conceptual frameworks. In doing this, I show that health needs are different to healthcare needs. In this regard, this study is concerned with basic healthcare needs, which are usually provided by primary healthcare facilities and personnel, unlike health needs, which include nutrition, hygiene/sanitation and lifestyle facilities. A need to assess both objective and subjective aspects of healthcare needs and accessibility is also underscored, which informs the adoption of a mixed methods research design in this thesis. Finally, I show that the concerns addressed in this research project, which is situated in geographies of healthcare services (in LMICs), are also topical in other research fields, especially Development Studies.

8.1.1 Research Aim, Objectives and Methodology

Against the foregoing background, the overall goal of this doctoral research project is to comprehensively analyze small-area need and accessibility of primary healthcare services in Nigeria through a case study of Kogi State, with a view to discursively exploring people's experiences and perspectives in extreme Medically Underserved Areas (eMUAs). The purpose is to gain a thorough understanding of the status quo, from both objective and subjective perspectives, with a view to making policy-relevant recommendations. To this end, the research objectives are: (1) develop a synthetic small-area zoning system that is optimized for the current study; (2) derive some small-area estimates of primary healthcare needs, which are also consonant with standard health-related development indicators; (3) analyze small-area variations in spatial accessibility of primary healthcare services and (4) explore the discursive experiences, perceptions and perspectives of healthcare access in extreme Medically Underserved Areas (eMUAs).

To accomplish the foregoing objectives, both secondary spatial datasets and primary qualitative data are utilized in an 'explanatory sequential mixed methods research design', in which spatial analytics is both dominant and precedent (Morse, 2003; Brannen, 2005; Creswell and Clark, 2018a; Creswell and Creswell, 2018; McBride *et al.*, 2019, p. 699; Meixner and Hathcoat, 2019, p. 63). With spatial datasets, objectives one (1) to three (3) are achieved by synthesizing a corpus of advanced spatial analytics, including: Automated Zone Design method, Spatial Microsimulation Modelling (SMM), and Generalized Two-Step Floating Catchment Area (G2SFCA) method. This geocomputation workflow also entails innovative exploitations of gridded demographic datasets (from the WorldPop Project) in order to obtain outputs that are more robust than existing works, as discussed further below. Following this, qualitative methods are used to meet the fourth research objective, in which framework thematic analysis of the focus group discussions is performed (Green and Thorogood, 2004a, p. 184). Not only does this help address some popular critiques of spatial analytics by incorporating relevant humanistic (and cultural) aspects (Johnston and Sidaway, 2016c, p. 170; 2016b, pp. 159 - 162), it is also instrumental to the actualization of other axiological dimensions of this study, especially the necessity of inclusivity and 'giving voice to' (enfranchising) underserved population subgroups (Gesler and Kearns, 2002, p. 159; Commission on Social Determinants of Health (CSDH), 2008).

8.1.2 1st Objective: Optimized Small-Area Analytical Zones

The lack of mappable small-area geographies in Nigeria is the primary motivation for developing a bespoke analytical zoning system that is optimized for this study, which serves as its operational spatial units (and scale) of demographic data aggregation. Not only does the vector data model of GIS provide a more realistic analysis of spatial accessibility than the raster data model (Shahid *et al.*, 2009; Delamater *et al.*, 2012), the complexity of location and routing problems is reduced by vector-based need aggregation, even though this comes with important implications, such as aggregation-induced errors (Cromley and McLafferty, 2012, p. 362). In addition to overcoming the limitation of data unavailability, this optimized zoning system helps to mitigate other well-known pitfalls of using readily-available aggregate zonal data (from public sources) for spatial analytics of healthcare need and accessibility (Bell *et al.*, 2013; Gautam *et al.*, 2014, p. 12; Chen, 2019). Furthermore, the optimized zoning system developed for this study makes it possible to ingrain the notion of equity in its foundation and fabric in a powerful way that is yet to be conceived and implemented by other similar studies, especially in the study area (and other similar LMICs). In addition to mitigating aggregation-induced errors in the subsequent analysis of spatial accessibility, population-weighted centroids derived from the optimized analytical zoning system form an optimal constellation of potential locations for primary healthcare facilities, with which optimized spatial re-configuration and/or expansion of healthcare services can be achieved, using Location-Allocation Modelling. Indeed, the notion of optimality operationalized in the zoning system of this study both incorporates and balances the dialectical concepts of equity and efficiency[90] (Le Grand, 1992c; McDaid and Sassi, 2011; Kelly *et al.*, 2015, p. 1467; Hu *et al.*, 2019), such that it became possible to endogenously/inductively answer the fundamental question: how many optimal small-area zones should the study area comprise? Thus, the necessity of optimized small-area analytical zoning systems for the analysis of healthcare cannot be overemphasized (Coombes, 2000; Shortt *et al.*, 2005; Wang, 2020, p. 5). Consequently, following standard zone design criteria, the optimized small-area zoning system developed for this study is made up of 341 contiguous zones, with an average zonal population of about 15,000 people. This zoning system incorporates two extra modelling criteria, which though greatly enhances its realism, makes the modelling process significantly complex. Firstly, important natural barriers are respected, specifically the two major rivers which transect the study area. This is an intuitive formalization because it is implausible for small-area zones to be bisected by large rivers, which would create an unrealistic within-zone discontinuity. Secondly, at the same time, the three senatorial districts of the study area, which serve as the main sociocultural distinctions, are also respected by ensuring that every derived zone is mutually exclusive to one senatorial district. Therefore, no synthetic zone belongs in more than one sociocultural unit, as expected. These are nontrivial feats to simultaneously accomplish with automated zone designs as exemplified by a dearth of studies with these attributes (see for example Mokhele *et al.* (2016)). Lastly, I suggest that socio-spatial inequalities in the study area are reinforced by the extant suboptimal zoning system, which is a product of problematic historical political processes that manifest as gerrymandering (Lewyn, 1993; Kalcsics, 2015, p. 598). It is therefore necessary for researchers and policymakers to be wary of the use of these zoning systems for equity-sensitive purposes (Bullen *et al.*, 1996), including the collection of development-related data by international organizations like the DHS and UNICEF.

[90] These concepts are often regarded to be contradictory, such that the pursuit and achievement of one is typically at the expense of diminishing the other.

8.1.3 2nd Objective: Small-Area Estimates of PHC Needs

Unlike other purely statistical methods, SMM is the only explicitly geographical method for small-area estimation of healthcare needs, especially when there is a necessity to simultaneously incorporate multiple variables (Rahman and Harding, 2017, p. 16). On top of this, the precision of estimates of aggregated need population has dire consequences for the analysis of spatial accessibility, which are disadvantageous for rural areas (Langford and Higgs, 2006). Unlike many previous studies that are inattentive to these aspects, the current study mitigates potential downsides of poor estimations of healthcare need. From Multiple Indicator Cluster Survey (MICS 5) microdata, eight (8) standard indicators that relate to HIV/AIDS and sexual behaviour are estimated (and mapped) at a small-area scale. In tandem with a need to illuminate inequalities using the PROGRESS framework (O'Neill *et al.*, 2014), these indicators are also disaggregated according to relevant socioeconomic dimensions in order to explicate socio-spatial variations (WHO, 2015, p. 56). From these standard small-area indicators, the zonal population of sexually active people also serves as one of the need variables for computing relevant small-area indices of spatial accessibility, particularly family planning services. In addition to creating small-area estimates of standard health-related indicators from disparate multivariate data, the outputs make it possible to establish more robust links (even at individual levels) with other mesoscale models; thereby enabling spatial analytics to be more responsive to evidence-based policy making in LMICs (Foley *et al.*, 2009; Morrissey *et al.*, 2013b; Eide *et al.*, 2018; UNDP, 2018, p. 23).

8.1.4 3rd Objective: Spatial Accessibility of PHC Services

Whereas other similar studies analyze the geographic accessibility to PHC facilities (Mansour, 2016; Manjia *et al.*, 2018; Hu *et al.*, 2019; Lawal and Anyiam, 2019), which have now been shown to be of limited fidelity, especially in LMICs like Nigeria; this study considers the diversity of healthcare services provided at each primary healthcare facility as well as the associated service supply quantity (Tanser *et al.*, 2010, p. 571; Cromley and McLafferty, 2012, p. 308). Other studies on spatial accessibility have also implemented relatively less sophisticated methodologies than the current one; therefore, the realism of the findings of those studies may be dubious. In addition to using optimized small-area analytical zones and precise estimates of healthcare need, this assures that the analyses (and mapping) of primary healthcare accessibility in this study is more accurate and precise than other similar studies of the study area. This is more so that a sophisticated algorithm for analyzing spatial accessibility, the ONN-G2SFCA method, was implemented based on realistic estimates of travel-related impedance, travel time, which features variations in travel speed based on road type/quality (Wang, 2014b, p. 100). In so doing, genuine small-area variations in spatial accessibility are revealed, including eMUAs (Ricketts *et al.*, 2007; Gentili *et al.*, 2015). Among other things, this study is consistent with other works in confirming that urban areas have much better accessibility than rural areas. In this regard, the administrative capital of Kogi State, Lokoja town, enjoys by far more primary healthcare accessibility than anywhere else in the study area. However, unlike existing analyses of the study area, the computation of small-area accessibility indices and their subsequent aggregation unto large politically aligned zones reveals the undesirable tendency for localized pockets of acute deprivation to become concealed/masked in this process (UNDP Nigeria, 2016, p. 61; AbouZahr *et al.*, 2017, p. 12). Of the three senatorial districts in the study area, Kogi East which is the most populous (constituting about 45% of the entire study area population) has the worst healthcare accessibility. Whereas, Kogi Central has the best healthcare accessibility, mainly because its population is clustered in small densely packed towns and communities, owing to the rugged and rocky topography of the same senatorial district. In addition to showing that PHC accessibility is a more realistic measure than availability, the use of detailed information on available service types and quantity as well as service-specific need quantity, are invaluable for comprehensive analysis of spatial accessibility, which many studies tend to ignore.

8.1.5 4th Objective: Emplaced Experiences of PHC Needs and Accessibility in eMUAs

In geographies of health, the notion of emplacement is central to perceptual and experiential facets of both health conditions and the resulting care-seeking behaviours thereof (Gesler and Kearns, 2002; Kearns and Collins, 2010; Andrews and Crooks, 2012, p. 31; Gatrell and Elliott, 2015b, p. 101). Thus, some of the pathways by which place affects perceived health in the study area are revealed. The lived experiences of people with health conditions are also explicated to the extent that these mediate their health-seeking behaviours in different localities. In so doing, further insights into the mechanisms of, and association between felt/perceived access and potential access are elicited (Fortney *et al.*, 2011). Furthermore, the healthcare expectations of the local population are explored in order to ensure that relevant interventions, including possible prescriptions for enhanced socio-spatial reconfiguration and/or expansion of healthcare services, are socio-culturally compatible with the desires of potential users in the study area. This responds to the need for health geographers (especially in LMICs like Nigeria) to account for people's perceived healthcare access, relative to their potential access, as well as the potential role that relevant geodemographic and sociocultural markers may play in shaping these (Gatrell and Elliott, 2015a, p. 101; Eide *et al.*, 2018).

Extreme Medically Underserved Areas (eMUAs) are observed to be both very remote and rural; therefore, they lack many basic social amenities. Consequently, it is not surprising that the qualitative analysis reveals a plethora of serious disincentives to meeting primary healthcare needs in these contexts. In eMUAs of Kogi East and West senatorial districts, travel-related impediments are paramount, including: (1) long travel time to good healthcare facilities, (2) unavailability and/or inconvenient and/or risky transportation mediums which also exhibit diurnal variations, (3) very expensive transportation options, (4) very poor road infrastructure and (5) very limited alternatives for obtaining necessary healthcare. Whereas in eMUAs of Kogi Central senatorial district, the main impediments are: (1) excessive queues and long waiting times at available healthcare facilities, (2) poor quality of healthcare services resulting from a lack of equipment and supplies, and (3) poor attitude of healthcare personnel. Overall, desired interventions include: (1) constructing good access roads for eMUAs (2) renovating and/or upgrading existing healthcare facilities as well as building new ones which function efficiently; (3) poverty eradication as well as empowerment initiatives and (4) the provision of basic social amenities. Not only do the foregoing issues validate some aspects of the precedent spatial analysis of accessibility, but they also assure that the findings of this study are attentive to and inclusive of the study population.

8.2 Concluding Remarks

In contrast to gridded/raster representations of demographic data, aggregated polygons are more applicable to the analysis of spatial accessibility for a number of reasons (Kwan and Hong, 1998; Shahid *et al.*, 2009; Schuurman *et al.*, 2010; Delamater *et al.*, 2012). First, it is well established that vector-based accessibility analysis is more robust than raster-based variants, not least because an advanced transportation network can be modelled with vector data models. This vector-based network model is capable of considering various aspects of transportation-related disincentives such as travel speed for various road types and transportation mediums, turn- and one-way restrictions, diurnal differences in traffic (amongst other factors), which cannot be adequately modelled with raster-based implementations. Second, a crude vectorization of continuous raster grids to regular rectangular tessellations is fraught with many problems (and therefore is not only counter-intuitive but also sub-optimal). At a fundamental level, the resulting tessellation falls short of well-established requirements of optimized analytical zoning systems for statistical data aggregation and spatial analysis and mapping. In socioeconomic applications of spatial analysis, data aggregation is usually necessitated by a need to achieve a parsimonious reduction of data in order to eliminate needless analytical complexities (especially in location and routing applications), and by so doing, to avoid large statistical problems and reduce computer processing time (Diehr, 1984; Cromley and McLafferty, 2012, p. 362). The development and use of an optimized small-area analytical zoning system are not only adept at mitigating most of the downsides of using aggregate data for spatial analytics, but also helps to elicit real small-area variations (SAVs) in the spatial accessibility of primary healthcare services. Furthermore, need aggregation issues such as aggregation-induced errors in location modelling are mitigated while ensuring that an optimum number of potential demand (and supply) points are used, which are located mainly at places where potential demand is actually present (i.e. population-weighted centroids) (Francis *et al.*, 2009; Francis and Lowe, 2015).

Despite developing and utilizing optimized analytical small-area zoning systems for spatial analysis purpose, they still fall short of many of the downsides of choropleth maps (Cromley and McLafferty, 2012, p. 119; Monmonier, 2018). Essentially, they tend to misrepresent mapped information by illuminating or concealing some aspects (Cromley and McLafferty, 2012, p. 115). This may even be exacerbated by optimized small-areas zoning systems in study areas like the current study, which comprise great disparities in population density, such that very densely populated areas get to be represented by one BBA (such as the 1 km^2 hexabins of the current study) whereas places with very low population densities have large zones. Consequently, very densely populated places become almost concealed in choropleth maps of optimized small-area zoning systems. This situation is exemplified in Figure 6-15, in which it is not apparent that Kogi Central Senatorial district has the best PHC spatial accessibility in the study area. In order to overcome this downside, it is often helpful to complement choropleth maps with relevant statistical charts like frequency histograms or cumulative frequency plots (i.e. ogives) (Cromley and McLafferty, 2012, p. 125). Both approaches are employed in the current study such that the specific number of small-area zones in each accessibility category is shown in Figure 6-15 whereas the ogive plot in Figure 6-18 corroborates Figure 6-15 by showing what level of SPAI is enjoyed by various percentages of the need population on the senatorial districts. In this way, it becomes apparent that Kogi Central generally has the best PHC accessibility whereas Kogi East has the worst.

In Chapter 7, I demonstrate that multiple dire experiential indicators of inaccessibility operate in concert to reinforce themselves in eMUAs at every phase of the three-delays model. I also show that social exclusionary mechanisms act both to create and perpetuate access-related disincentives and, at the same time, disable/discourage options for mitigating these difficulties. Whereas sociocultural differences are more relevant to perceptions of need, it is the relationships between the spatial organization of settlements and the topography that mostly informs variations in (perceptions of) spatial accessibility in the study area. In this regard, while a rugged topography enables enhanced accessibility amidst limited service availability in some localities (especially in Kogi Central), the reverse is the case in the other senatorial districts.

In sum, the findings of this doctoral research project suggest that the concept and framework of social exclusion are helpful in problematizing, analyzing, explaining and understanding the scarcity and inequitable access of essential healthcare services in the study area (Atkinson, 1998; Labonte, 2004; Health Inc Consortium, 2014). According to Health Inc Consortium (2014, p. 12), social exclusion "can varyingly be considered as a condition/status or as a multidimensional and dynamic process". Viewed as a condition/status, social exclusion refers to the outcome of the exclusion of individuals or groups as a result of their social identity (religion, gender or race) or social location (segregated territories, remote areas, or low paid jobs), making them unable to fully participate in society. Conceived as a multidimensional and dynamic process, social exclusion hinders individuals from attaining a decent livelihood, a state from offering equal citizenship to its citizens or a country from reaching a sufficient level of human development, as a result of social interactions and organizational/institutional barriers. "Social exclusion therefore generates, sustains and reproduces poverty, enhances inequalities, and restricts social, political and economic participation for some marginalized individuals or groups and prevents them from accessing institutional sites of power or engaging with powerful organizations." (Health Inc Consortium, 2014, p. 12). The concept of social exclusion is therefore one of the key transversal themes in the investigation of the causes and consequences of health(care) inequalities (Popay *et al.*, 2008a). By presenting a framework through which the social, political, economic, cultural and institutional dimensions of society shape human vulnerabilities, the concept of social exclusion is invaluable in the qualitative analysis of healthcare coverage and its inequality, such as the current thesis (Babajanian and Hagen-Zanker, 2012). In this regard, people in landscapes of extreme healthcare deprivation in the study area are considered to be experiencing a condition/status of social exclusion by virtue of their spatial locations (i.e. residing in remote rural areas), which intersects with other aspects of social disadvantage. Consequently, these groups are unable to access and/or engage with institutional sites of power (i.e. primary healthcare services). The mechanisms that underpin the dearth and unequal accessibility of basic healthcare services in the study area are complicated, deserving further research investigation.

In conclusion, there are two main proximal aspects to resolving the challenges of healthcare accessibility in the study area: (1) improving the quality of road infrastructure in eMUAs and (2) ensuring an optimal socio-spatial configuration of primary healthcare facilities. Furthermore, basic social amenities should be provided in eMUAs as a way of ensuring the retention of healthcare personnel in these remote rural contexts that are acute healthcare deserts. This is premised on the realization that problems of poor healthcare accessibility result from broad mechanisms of social exclusion. Consequently, it is crucial that holistic interventions are enacted to mitigate relevant aspects of social exclusion in the study area, since previous efforts at addressing only proximal concerns of healthcare accessibility have proven unsuccessful (Labonté and Laverack, 2008; Carey, 2014; Carey *et al.*, 2015b; Carey and Crammond, 2017). Indeed, this requires better synergy amongst Ministries, Departments and Agencies (MDAs) of health in Nigeria as well as other relevant public MDAs, such as the Ministry of Transport and agencies for rural development.

8.2.1 Contributions to Knowledge

Through an interrogation of extant zoning systems, I show that the current (political) districts are problematic, not least because they tend to embody elements of gerrymandering (Rush, 2000; Birkin *et al.*, 2002, p. 109; Chou and Li, 2006), and as such reinforce socio-spatial inequalities in the study area. In their stead, I develop a robust method for creating synthetic zoning systems from scratch in data-scarce contexts like the study area, which is also optimized for the analytical purpose of the current study. In so doing, I demonstrate how the lack of appropriate and rich socio-spatial data for small-area analysis of accessibility in LMICs can be overcome through the innovative exploitation of recently available data types that are not conventional for this type of spatial analytics (Ozdenerol, 2016, p. 149; UNDP, 2018). Not only does this support existing evidence that in healthcare studies, the boundary configurations of extant political/administrative units matter (Shortt *et al.*, 2005; Flowerdew *et al.*, 2008); it shows that districting problems are both extremely crucial and complicated in developing contexts for a multitude of multiscale contextual reasons.

This study demonstrates the possibility of computing small-area multivariate estimates of standard health-related development indicators, with the microdata of national sample surveys, using the HIV/AIDS and Sexual Behaviours Indicators of UNICEF's MICS 5 as an exemplar (UNDP, 2018, p. 23). Not only is this useful for informing evidence-based policy-making and small-area targeting of relevant interventions, but it also provides specific small-area need estimates for computing relatively precise indices of spatial accessibility of primary healthcare services (such as family planning services in the current study) (Carey *et al.*, 2015b; Carey and Crammond, 2017; Bekker *et al.*, 2018; Rahman and Wazed, 2018). Furthermore, these health-related indicators are disaggregated according to relevant socioeconomic dimensions beyond the standard disaggregation framework of the original MICS 5 template (WHO, 2015, p. 56). Thus, in addition to the standard socioeconomic variables in the data reporting template for Nigeria, variations in sexual behaviour according to ethnicity and religion are revealed. To the researcher's knowledge, this is the first time that such an output is produced for a study area in Nigeria.

There is a paucity of studies on the accessibility of primary healthcare; rather, researchers tend to focus on one specific healthcare service (Rosenberg, 2016, p. 2). Among other things, I explain in Section 2.2.3 that service-specific or piecemeal approaches are problematic in that they undermine the PHC approach which is well-recognized as the overarching strategy for actualizing the UHC goal, especially in LMICs like the study area (Crooks and Andrews, 2012; WHO, 2013b; Kickbusch *et al.*, 2015). Thus, by comprehensively analyzing the service-specific accessibility of a corpus of baseline healthcare services, which together form PHC accessibility, the current study fills this important knowledge gap while also advancing the frontiers of knowledge in other crucial ways as discussed further. This approach is supported by the notion of "primary healthcare under one roof" (Crooks and Andrews, 2012; Sharma *et al.*, 2013; Rumball-Smith *et al.*, 2014), which is also accentuated by Nigeria's PHC strategies and plans (NPHCDA, 2018a). I show that in the study area, there is a marked difference between hospital availability and PHC service availability. At the same time, the mere presence of a healthcare service does not suggest that it is of commensurate quantity for the needy population. Unlike existing studies that either focus on the healthcare facilities or only one select service for accessibility analysis, this study considers a modicum of primary healthcare services which are considered invaluable to the UHC goal of Nigeria. In doing this, spatial variations in small-area accessibility of primary healthcare are elicited at various spatial scales and explicated (Gautam *et al.*, 2014; Gentili *et al.*, 2015), starting with the very fine scale of the synthetic wards through to contextually relevant large zones that typify relevant socio-cultural differentiation in the study area. Small-area data makes it possible to show more detailed and finer-grained spatial patterns than can be shown with large-area data, thereby resulting in better insights from research works (Cromley and McLafferty, 2012, p. 132; Goodman and Goodman, 2017).

Lastly, by discursively exploring experiences and perspectives of people living in eMUAs, this study forges a deep understanding of their lived experience with particular emphasis on perceptions of health conditions and how these mediate and/or are mediated by perceptions of access. In so doing, the effects of place/context are foregrounded through a consideration of both physical and socio-cultural aspects that are local. Overall, I suggest that the mechanisms which drive poor healthcare access are both intricate and context-specific. Nevertheless, these are mediated by concurrent effects of multiple intersecting axes of various disadvantages, which are both proximal and distal to the access conundrum and at the same time operate at multiple spatial scales (Levitas *et al.*, 2007, p. 86; Bailey *et al.*, 2018). Thus, I highlight social exclusion as an overarching framework for understanding both objective and subjective dimensions of healthcare needs and access in the study area.

Some implications and recommendations of the current research project to policy and practice are discussed in the next section with a focus on the objective aspects of potential spatial accessibility.

8.2.2 Implications/Recommendations for Policy and Practice

It is crucial to move beyond nationwide (or large-area) indicators of development which mainly serve the interest of international organizations and donor agencies, to small-area development indicators which are very useful for policymaking, local-level planning and intervention targeting (Carey *et al.*, 2015b; Wollum *et al.*, 2015; Carey and Crammond, 2017; Eslava-Schmalbach *et al.*, 2019). Not only do national-level indicators of sustainable development mask pockets of extreme disadvantage within LMICs, by so doing, they also reinforce extant inequalities in these contexts – an undesirable outcome (UNDP Nigeria, 2016, p. 61; AbouZahr *et al.*, 2017, p. 12; Cuadros *et al.*, 2017). This is evident in Section 6.3.3. The creation of small-area statistics of relevant development indicators will require more (financial) investments in the collection of rich data about human-social aspects, amidst the dire resource constraints in many LMICs (Higgs, 2009, p. 890; UNDP, 2018, p. 23). While the capacity to improve data collection is being increased, sophisticated quantitative methods, such as those implemented in the fourth and fifth chapters of this thesis, can be used to bypass or address extant data limitations in the meantime.

The effect of extant zoning systems on variations in healthcare access are foregrounded in this thesis, effects which have been completely ignored by other studies and development initiatives in the country such as UNICEF and DHS. The clear implication of this is that international efforts at supporting development initiatives in LMICs like Nigeria may actually be reinforcing extant inequalities (Ajebon, 2019, p. 119; Ballas *et al.*, 2019, p. 72). This unwanted effect can be mitigated by creating and utilizing bespoke zoning systems for development initiatives like health(care), which though are independent of extant political zoning systems, can be reaggregated to current political zones if necessary, just as is performed in the current study. This is an expedient approach because the existing power hierarchies in Nigeria means that despite the apparent inequities in the extant political zoning systems, remediating them is barely possible since it tends to further privilege some already advantaged population subgroups, enabling the perpetuation of their political power. Ideally, political districts are not supposed to be static as we currently have in Nigeria; rather, they ought to be routinely revised (preferable decennially as with the annual censuses) in response to inevitable population changes which are occasioned by variations in migration as well as fertility and mortality rates (Kalcsics, 2015, p. 597). However, considering that these revisions would be associated with political tensions and therefore difficult to actualize in a politically unstable country like Nigeria (Hill, 2012; Campbell, 2013), it is only necessary to disentangle health districts from political districts as was the case before the year 2001 (NPHCDA, 2018b, p. 29). By so doing, even if existing political complications undermine necessary routine reviews of political wards, official revisions of health districts become possible, either by 5-year periods in tandem with the lifespan of NSHDPs or by 15 years periods in consonance with the lifecycle of National Health Policies (NHPs). The currently recommended health districts should be designed and created (as maps) using robust automated zone design methods, such as Chapter 4 of this research project demonstrates. Bespoke health districts should also be given necessary legislative/legal backing from both the National Health Acts and the National Health Policy so that they are protected from haphazard modifications for political reasons (like the Pre-2001 ones) until the legal end of their lifespans.

With regards to the geographic aspects of healthcare access, Nigeria's current official policies, plans and strategies (i.e. the National Health Act, 2014; the National Health Policy, 2016; the NSHDP II, 2018 and the WHS 2018) are mainly concerned with healthcare availability aspects; that is, per capita supply, as discussed in Section 6.3.2. However, in the access conundrum, availability, which is at the lowest level, is not synonymous with accessibility (Tanahashi, 1978; Penchansky and Thomas, 1981; Evans *et al.*, 2013). Therefore, whereas a zoning system is helpful for supporting the determination of the service/catchment area for a healthcare facility, which serves as the platform for service delivery in a region, it should not be the only criteria for planning spatial accessibility in a large region. A robust plan for improving accessibility ought to comprise a zonal aspect as well as a travel distance/time aspect. In this way, a zoning system fulfils the requirement of ensuring that a constellation of facilities are sited in such a way as to assure a minimum population to support their sustained patronage while at the same time minimizing competition from neighbouring public services, a notion known as "cannibalism" in business geography (Birkin *et al.*, 2003; Church and Murray, 2009, p. 236; O'Kelly, 2009, p. 429). The travel aspect should determine the maximum/average distance that potential users are expected to travel in order to reach a healthcare facility. Indeed, the latter aspect of this proposed plan is known as service districting (Blais *et al.*, 2003; Benzarti *et al.*, 2013; Kalcsics, 2015, p. 601), implying that both inductive and deductive modelling processes should be invoked in designing an optimal constellation of PHC services in Nigeria. These two aspects correspond with the notion of 'threshold' and 'range' of the Central Place Theory (Christaller and Baskin, 1966; Andrews and Crooks, 2012, p. 29), which remains an efficient planning framework for realistically designing a constellation of facility locations for PHC service provision in developing contexts (Kearns and Collins, 2010, p. 21; Meade and Emch, 2010, p. 419). Policies and plans that combine both threshold and range aspects ensure the realization of an optimal constellation of PHC facilities whose supply capacity is proportionate with estimates of potential utilization (derived from appropriate Spatial Interaction Location-Allocation (SILA) models) (Humphreys and Smith, 2009, p. 74). For instance, a better plan to enhance the spatial accessibility of PHC services in Nigeria can be: 'ensure that every locality with a minimum population of 15,000 people has at least a public PHC facility of proportionate size, while at the same time assuring that the maximum travel time to the closest public PHC facility is 15 minutes (by '*okada*') in rural communities and 20 minutes (by car) in urban areas'. This type of objective can be solved programmatically with appropriate optimization algorithms in about two steps (Birkin *et al.*, 2002). Territory planning is performed in the first step in which an optimized zoning system is developed, ensuring that the desired minimum population threshold is achieved (such as Chapter 4), the centroids of the optimized zones serve as potential PHC facility sites for the subsequent step. In the second step, an appropriate L-A model is used to choose (from potential PHC facilities) the sites which ensure that no one travels beyond the specified range (i.e. 15 or 20 minutes accordingly).

Nevertheless, the extent to which relevant healthcare agencies would be willing to take on evidence-based options from research like this is contentious. This is because this may undermine some probable vested interests of relevant power hierarchies in the policy-making and/or healthcare sectors of the country. For instance, even though an optimal constellation of healthcare services will be both cost-efficient and equitable, this would mean having to establish fewer new healthcare centres in the country. The implication is a reduction in the national budget for this activity, which may not be welcomed by relevant power brokers in the health sector. It is well-known that due to widespread corruption in the civil service, these budgets are often inflated with a motive that relevant contracts would be given to allies of powerful people in government who also receive kick-backs (or illegally siphon off public funds in the process) (Kinnan *et al.*, 2011, p. 27; Hope, 2017).

Many objective and subjective studies on spatial access are not sensitive to some of the insights from this project, not least because many of these insights are peculiar to developing contexts. For instance, it is unlikely for healthcare services/facilities in High-Income Countries (HICs) to be acutely substandard wherever they exist, unlike in LMIC contexts. In such HIC contexts, the presence of a facility may automatically imply that quality PHC services are being rendered. Apparently, this is not the case in the study area, as with other LMIC contexts. Various localities in LMICs could also possess very different quality of road infrastructure, which would exert adverse effects on both healthcare access and overall social exclusion in such places. Furthermore, through an exploration of the lived experience of people in eMUAs, in Chapter 7, a nuanced picture of the multitude of context-specific ways in which access is mediated by non-physical interlocutors is painted. This includes: (1) cultural and demographic influences on both lay cognition of health conditions and the care-seeking behaviours that become espoused; (2) higher dimensions of the access conundrum, including: acceptability of various types of healthcare providers, issues of healthcare personnel, matters of cost and affordability, power dynamics in healthcare settings and associated socio-political mediators, as well as the quality and effectiveness of healthcare. Therefore, holistic and intricate aspects of primary healthcare access in Nigeria, particularly Kogi State, have now been revealed in this study, beyond what is available in existing works.

Variations in socioeconomic factors are fundamental determinants of individual health condition and mortality (Krieger, 2011; Woolf and Aron, 2013, p. 163; Cockerham, 2017, p. 91). Therefore, in line with the intervention strategy of 'universal proportionalism', policies for social welfare and social protection of the most vulnerable population groups should be enacted and implemented in a sustainable manner with a view to mitigating both poverty and poverty-induced health conditions (Institute of Medicine, 2000, p. 9; Benach *et al.*, 2013; Carey *et al.*, 2015a). These ought to be based on sound population data with which the socioeconomic status of a population can be ascertained in order that such social welfare schemes are appropriately targeted (Carey, 2014; Carey *et al.*, 2015b; Anderson *et al.*, 2017; Carey and Crammond, 2017; Rahman and Wazed, 2018). Among other things, this assures that relevant interventions do not result in an undesirable increase of socio-spatial inequity in the study area (Frolich and Potvin, 2008; McLaren *et al.*, 2009; Lorenc and Oliver, 2014; Lloyd *et al.*, 2017; Eslava-Schmalbach *et al.*, 2019, p. 8), a notion sometimes referred to as "intervention-generated inequalities" (Lehne and Bolte, 2016). Current attempts at implementing social welfare schemes (such as 'conditional cash transfers' and the N-Power Programme[91] of the federal government) have been received with extreme scepticism and criticism by various sectors of the country because they are not data-driven but rather politically motivated. In this way, not only are the methods for determining beneficiaries unclear if not problematic, but these also serve as vehicles for further embezzlement of public

[91] N-Power Programme is a recent initiative of the federal government aimed at development or acquisition of vocational skills by unemployed youths in Nigeria, with a view to stimulating the domestic economy. See https://www.npower.gov.ng/about-us.html (Accessed 27/06/2020)

funds since there is often no way of accounting for public expenditure on these schemes (Uzochukwu, 2017).

8.3 Research Limitations with Potential Improvements

With the use of disparate data sources comes the problem of input datasets with different date stamps. This study is therefore susceptible to a number of data issues which are well-documented elsewhere (Garb and Wait, 2011, p. 345); nevertheless, in this thesis, these effects are mitigated as much as possible with the aid of the sophisticated methods employed as well as adequate attention to details and accuracy all through the data analysis workflow. Further aspects of the known limitations of this thesis are considered in the following sub-sections.

8.3.1 Spatial Microsimulation Modelling

From anecdotal evidence, spatial patterns for both ethnicity and religion are likely to be unreliable because none of the spatial constraints is known (or likely) to have a significant correlation with these two in the study area. In other words, sex, age, wealth and educational level are not known to be significantly correlated with ethnicity or religion in the study area. Future work will benefit from having either ethnicity or religion as spatial constraints because in the study area, any of these would serve as a good predictor of the other. Data on the religious composition of the study area's synthetic zones would be almost unobtainable because this type of data is deliberately being suppressed by the government (notice that it is not collected in the census, neither is it part of the MICS 5 standard disaggregation attributes). However, reliable data on the ethnic composition of the study area is obtainable, albeit not very accurate. This will go a very long way in enhancing the fidelity of the resulting synthetic population in these dimensions.

For some of the spatial constraints, such as wealth/poverty and literacy, only a binary categorization was used instead of the full 4 – 5 categories in the MICS 5 sample survey microdata. This is a limitation of the gridded demographic data used for this project. New data sources offer opportunities to provide more spatial constraints, which will enhance the model fidelity. For instance, comprehensive data on rural/urban classification is now available from the Global Human Settlement - Settlement Model Grid (GHS-SMOD) (Pesaresi *et al.*, 2019).

8.3.2 Small-Area Analysis of Spatial Accessibility

Variations of catchment area size in this study have been explicitly implemented only at the second step of the G2SFCA analysis, the demand side. A more robust approach will be to also vary the catchment area size of the supply side (i.e. the first step of the G2SFCA) because more attractive/superior (or larger) service facilities are capable of attracting customers from more distant places (Birkin and Clarke, 1991; Roy and Thill, 2004). This is consonant with the formalization of advanced Spatial Interaction Models (SIM), called 'doubly constrained models' (Morrissey *et al.*, 2013a, p. 218; Morrissey, 2015). Since the attraction potential of service points is not restricted to their quantity of supply alone, catchment variation for this first step should be based on the potential quality or attractiveness of the various supplies as determined by relevant composite indicators, which could incorporate measures like hierarchy of services provided, number of services provided, number of personnel, quality of infrastructure and so on (Liu and Zhu, 2004). Nevertheless, by capping the number of potential services' points to be equal for every demand point, the attraction influence of a service supply point (no matter how large) will only be considered if such a supply point is amongst the specified minimum number of potential service supply points for a study area (as determined by the IDSO). Furthermore, potential customers are not always fully aware of all the attractiveness dimensions of various potential service opportunities prior to their first visit (Saurman, 2016). It may therefore be argued that the current consideration of service supply quantity as well as a distance-decay effect already accounts for (1) the improved accessibility of persons in relatively closer proximity to large service providers and (2) variations in service area catchments as a result of their ability to exert more weights at more distant demand points (owing to their large supply size).

Not all health personnel in each facility are involved in providing all the services offered, even though this is an implicit assumption of the current study. One implication of this is that for a specialized healthcare service like CS, the supply index should only be computed for facilities with a doctor, because only doctors are licensed to perform CS in the study area. Nevertheless, this study makes an implicit assumption that only facilities that have a full-time doctor would specify CS as one of the services offered. This is not always the case in reality because there are some part-time itinerant doctors who visit hospitals. This means that the actual spatial accessibility of the CS services in the study area could be worse than depicted in the current study.

There is also an implicit assumption that everyone in the study area travels by '*okada'*, which is not the case. Thus, this study considers one mode of travel; whereas, commuters exhibit multimodal transportation behaviour in travel to their choice healthcare facility (Ni *et al.*, 2019). Nevertheless, travel by *'okada'* is by far the most popular medium of transport in the study area, especially by socioeconomically disadvantaged people as well as rural dwellers who are the focus of this study. This explains why the extreme MUAs or HPSAs are the focus of qualitative primary data collection and analysis in Chapter 7. Furthermore, *'okada'* is an unsheltered medium of travel, implying that it is extremely susceptible to adverse weather conditions, especially tropical rainstorms and extremely high temperatures (as well as dust and wind storms, which seldom occur in the study area). *'Okada'* is also an inconvenient (and exclusionary) transportation medium; it cannot be utilized by some population sub-groups, such as frail/aged people and some who are physically challenged. Very sick or weak patients (who may need a stretcher) or pregnant women (in labour) have difficulties travelling by *'okada'*. Relative to cars, *'okada'* is much less safe because they are susceptible to falling sideways (because they are like a miniature motorcycle) and more prone to other forms of accidents when in motion. Indeed, many of these downsides of travelling by *'okada'* were raised by research participants and discussed in Chapter 7, as part of the qualitative analysis of this study. Despite these, it is sometimes the only (or fastest) medium of accessing some extremely remote places because of their very poor road infrastructure.

The lack of universally accepted standards of accessibility analysis constitutes a problem in terms of their use for the purpose of informing appropriate policy responses (Chen and Jia, 2019). There is a myriad of accessibility methods, as well as a variety of parameters (as discussed in Section 3.3.3). The possibility of utilizing various accessibility models (with diverse parameters) is problematic since different analytical results emanate from different accessibility measures and from diverse model parameters (Gautam *et al.*, 2014). This suggests that analysts may decide to choose accessibility models and/or model parameters that tend to support their (subconscious) inherent biases, thereby misinforming policymakers (Johnston and Sidaway, 2016a, p. 262; Monmonier, 2018).

A major limitation with most E2SFCA analyses remain the problem of overestimation or deflation of need and/or level of service supply (Wan *et al.*, 2012b; Delamater, 2013), which can be rectified by standardizing the travel impedance weights derived from the applied distance-decay function (Paez *et al.*, 2019, p. 35). By ensuring a proportional allocation of demand and service supply in an area, this standardization of demand weights helps to preserve both the system-wide need and supply estimates in the computation of an accessibility index. Although the extent to which this problem manifests in the current study is not considered, the 3SFCA method resolves this concern (Wan *et al.*, 2012b).

Edge effects which have been ignored in the current study (Pfeiffer *et al.*, 2008, p. 15), can be addressed by considering potential needs and supplies that are outside the study area but which are adjacent. However, this extensively increases the volume and complexity of data to analyze in the current study since it would also involve considering external places in the design of optimal small-area zoning systems, as well as transportation network modelling considerations. The determination of an IDSO is also complicated by the consideration of relevant variables outside of a study area.

8.3.3 Experiences and Perspectives of People in eMUAs

The worst-case scenarios of healthcare deprivations were identified for each sociocultural context. Since rural areas are expected to have much worse spatial accessibility than urban areas because of economic factors, this approach to the spatial selection of study sites precludes urban areas, which may also suffer from some dimensions of access aside from spatial accessibility. For instance, despite being physically closer to primary healthcare services than rural communities, poor people in urban localities may experience more severe limitations in negotiating the power hierarchies associated with obtaining healthcare amidst other more influential people of high social status. The high cost of healthcare provision in urban areas would also serve as a formidable barrier to healthcare utilization for poor people in urban areas. This selection bias can be overcome by double disaggregation based on both senatorial district and rural/urban dichotomy when determining sites for primary qualitative data collection (WHO, 2015, p. 56). In this way, differences in experiences and perspectives of people suffering from extreme healthcare deprivation in both rural and urban places can be explored and analyzed.

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Appendix A. Further Quantitative Methods and Materials

A.1 Chapter 5: Validating the Synthetic Population

A.1.1 Background to SMM Validation

The outputs of SMM are usually a synthetic population and then the small-area estimates thereof. The aim of validating this output is to gain an idea of the extent to which they are accurate, realistic, or reliable. This is an important aspect of data-generation methods such as the CO approach of SMM (employed in the current study) that implements a stochastic process; thus, it is not without discussion (Edwards *et al.*, 2011; Edwards and Tanton, 2013; Morrissey and O'Donoghue, 2013; Rahman *et al.*, 2013; Rahman and Harding, 2017). Two types of validation are differentiated: Internal and External (Edwards *et al.*, 2011; Edwards and Tanton, 2013). Internal validation compares the outputs of a SMM with the original inputs to estimate the extent to which the original inputs are emulated by the outputs. External validation involves the use of other datasets outside the input data for the model validation, or data available at a coarser spatial resolution than that of the original model (Tanton and Edwards, 2013b; Lovelace *et al.*, 2014). There are various statistical tests for SMM validation, such as: Total Absolute Error (TAE) and/or Standard Absolute Error (SAE) (Ballas *et al.*, 2007a; Tanton, 2011), the coefficient of determination of a regression model, i.e. the r-squared statistics (R^2), Standard Error Around Identity (SEI), equal variance 2-tailed *t*-test, Z-Score (Panori *et al.*, 2017) and chi-square (X^2).

The validation of SMM is an enormous challenge because the modelling is in itself required in order to estimate (small-area) data that otherwise does not exist due to any or a combination of reasons such as data collection cost, time and confidentiality (Edwards and Tanton, 2013, p. 250). In data-scarce environments like the study area, there often are not sufficient datasets for the SMM let alone having data for external model validation. This has also hindered the implementation of external model validation in some developed contexts, see for example, Edwards *et al.* (2011). Therefore, in this study, it is only possible to conduct internal validation. This entails producing various measures of goodness-of-fit statistics such as: Standard Root Mean Square Error (RMSE), Absolute Entropy Difference (AED), R Squared (R^2), Entropy (standard entropy measure), Chi-Squared (X^2), Total Absolute Error (TAE), Standard Absolute Error (SAE), Percentage Error (PE), Total Error (TE), Cell Percentage Error (CPE), Z^2, and Z.

A.1.2 Validating the SMM of Kogi State

Model validation is an essential step that assesses the extent to which a synthetic micro-population derived from SMM is reliable, realistic and accurate. This, in turn, is a proxy of the degree of reliability of other measures derived from the same synthetic population, such as the small-area multivariate SDG-related indicators computed in this chapter. Internal validation is performed in this study by comparing the outputs of the SMM (i.e. the synthetic population) with the original inputs (i.e. the sample survey micro-population and the spatial constraints) to estimate the extent to which the original inputs are emulated by the resulting synthetic population (Edwards *et al.*, 2011; Edwards and Tanton, 2013; Tanton and Edwards, 2013b; Lovelace *et al.*, 2014). This degree of modelling accuracy is assessed using all twelve (12) relevant goodness-of-fit statistics available in the FMF software, namely: Standard Root Mean Square Error (RMSE), Absolute Entropy Difference (AED), R Squared (R^2), Entropy (standard entropy measure), Chi-Squared (X^2), Total Absolute Error (TAE), Standard Absolute Error (SAE), Percentage Error (PE), Total Error (TE), Cell Percentage Error (CPE), Z^2, and Z. The FMF software interface used to compute these statistics is shown in Figure A-1, while the outputs of this operation are presented and discussed in the next section.

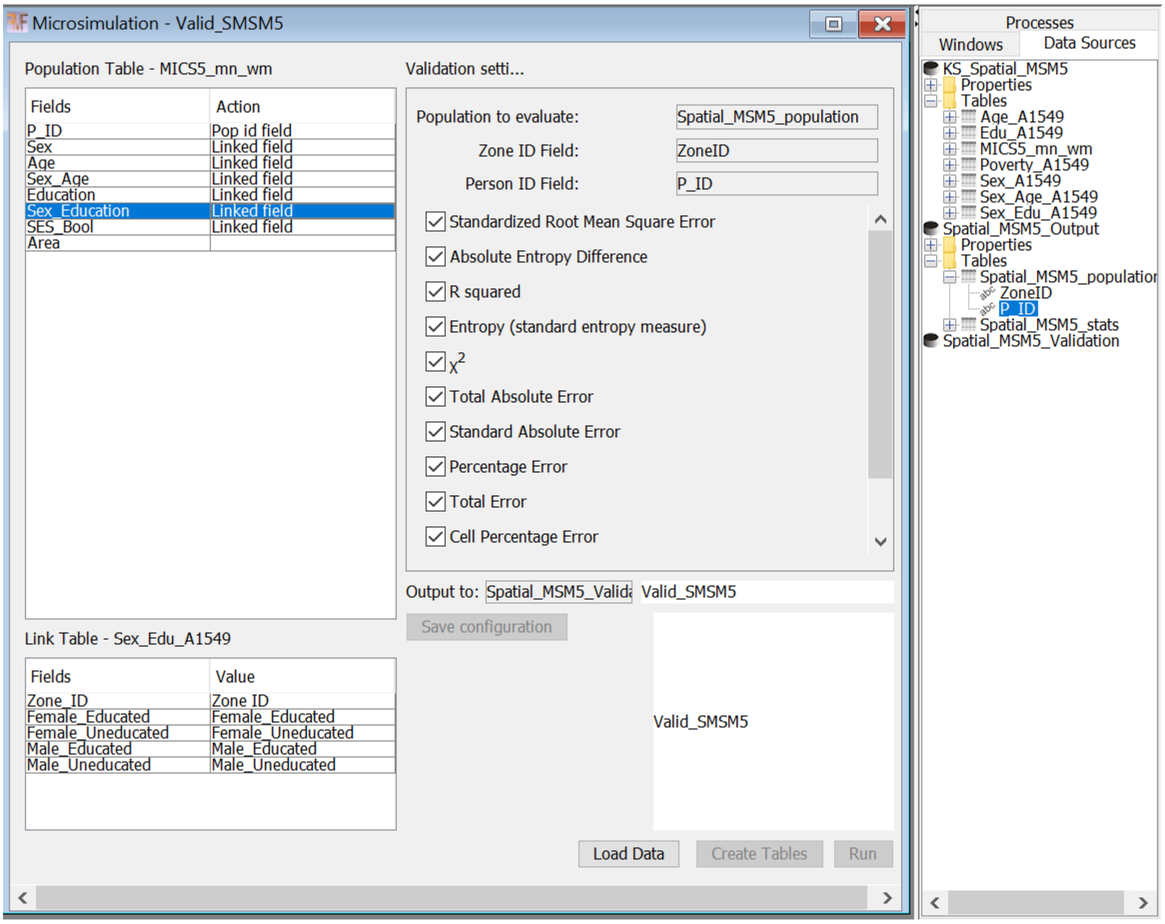


Figure A-1 The FMF Software configuration interface for validating the synthetic micro-population of persons age 15 - 49 in Kogi State, Nigeria.

A.1.3 Goodness-of-Fit of the Derived Synthetic Micro-Population: Internal Validation

It is crucial for the derived synthetic population to be validated before being utilized for further analytical steps. Not only does this assure that a given SMM is of acceptable quality, it ensures that potential analytical errors are not propagated unto further analytical operations. This explains why Step 4 of Figure 5-2, which is a validation of synthetic population, precedes synthetic small-area estimation (i.e. Step 5) and subsequent analytical steps in SMM.

Twelve (12) goodness-of-fit statistics highlighted in the preceding Section are computed to validate the SMM of the study area population. These are produced for each spatial constraint and each small-area zone, constituting a massive table of 342 rows by 73 columns. Therefore, this provides a measure of the validity of the model relative to the input variables (i.e. internal validation). Presented in Table A-1 is the goodness-of-fit statistics for each of the spatial constraints considered, while Figure A-2 are maps of two of these goodness-of-statistics (i.e. CPE and Z^2) for three spatial constraints, namely: Age, 'Age by Sex' and 'Sex by Education'. Squared Z is chosen for mapping because of its popularity in the relevant literature, while CPE is relatively easy to explain (Edwards and Clarke, 2009; Morrissey and O'Donoghue, 2013, p. 89). With higher values of SRMSE, AED, SAE, PE and CPE come more error in the model fit. The three spatial constraints mapped tend to have the least goodness-of-fit values, as shown in Table A-1 (also highlighted in orange colour); therefore, they deserve further considerations. Nevertheless, these error metrics are extremely low, being less than 0.08. This implies a very good internal validity of the derived synthetic micro-population of Kogi State.

Table A-1 Various goodness-of-fit statistics for the validation of the SMM of Kogi State

Variable Name	SRMSE	AED	R^2	Entropy	Chi^2	TAE
Sex	2.84E-05	4.02E-08	1	6.499267	0.002023	6
Age	3.40E-04	7.98E-06	0.999999	7.671999	0.323618	243
Sex by Age	6.99E-04	4.82E-06	0.999998	8.361252	1.429437	513
Education	1.24E-04	7.79E-06	1	6.331046	0.061976	114
Sex by Education	2.17E-04	3.27E-06	1	6.973711	0	175
Poverty	1.26E-04	4.35E-06	1	6.468207	0.041353	118

Variable Name	SAE	PE	TE	CPE	Z^2	Z
Sex	2.67E-06	1.33E-04	3	2.67E-04	5.06E-04	0
Age	1.08E-04	0.005402	121.5	0.010804	0.08323	0
Sex by Age	2.28E-04	0.011404	256.5	0.022809	0.367522	0
Education	5.07E-05	0.002534	57	0.005069	0.015504	0
Sex by Education	7.78E-05	0.00389	87.5	0.007781	0.098679	0
Poverty	5.25E-05	0.002623	59	0.005246	0.010353	-0.01036

Overall, based on the computed goodness-of-fit statistics, the SMM of Kogi State shows an excellent level of accuracy across all the spatial constraints employed. For instance, all SAEs (and TAEs and TEs) values are extremely low, with 'sex' exhibiting the best model fit and 'sex by age' having the least albeit negligible model fit. It is not surprising that 'sex' has the best model fit because it was specified as the reference spatial constraint used by the FMF software for determining zone totals; hence, it is the reference benchmark by which the accuracy of the synthetic population of this study is adjudged. Any constraint can be chosen as the reference variable an internal validation; however, sex was chosen because it is bivariate and tends to be a relatively accurate input data. This near-perfect SMM validity is exhibited by all the other computed goodness-of-fit statistics. For instance, R^2 values (i.e. coefficient of determination) typically range from 0 to 1, with 1 signifying a perfect model fit. Notice that the R^2 for all the constraint variables are approximately 1. Furthermore, a synthetic population is deemed not to fit if squared Z statistic is greater than the critical value (i.e. $|Z| > 1.96$) (Morrissey *et al.*, 2013b, p. 131).

Figure A-2 shows the spatial patterns of CPE and Squared Z for three spatial constraints, namely: Age, 'Age by Sex' and 'Age by Education'. These three spatial constraints tend to have the least goodness-of-fit values; therefore, they are likely to reveal problem small-areas as well as show substantial spatial variations in mapped data of SMM errors. Similar to Table A-1, Figure A-2 shows that 'Age by Sex' has the highest error of any small-area zone, with 16 zones having CPEs of between 5.42% – 10%. Age has the second-highest error, with 25 zones having CPEs of between 3.1% – 7.58%. Nevertheless, not only are these CPE values relatively low, only very few zones have these levels of error, that is 16, 25 and 19 zones (out of the 341 analytical small-area zones in the study area), for the 'Sex by Age', 'Age' and 'Sex by Education' spatial constraints, respectively. On the flipside, 45, 144 and 193 zones are 100% accurate in terms of CPE for the 'Sex by Age', 'Age' and 'Sex by Education' spatial constraints, respectively. These corroborate Table A-1 in demonstrating the very high internal validity of the SMM of the current study. The resulting synthetic population is therefore fit for use in subsequent aspects of this project, as exemplified in Section 5.4.

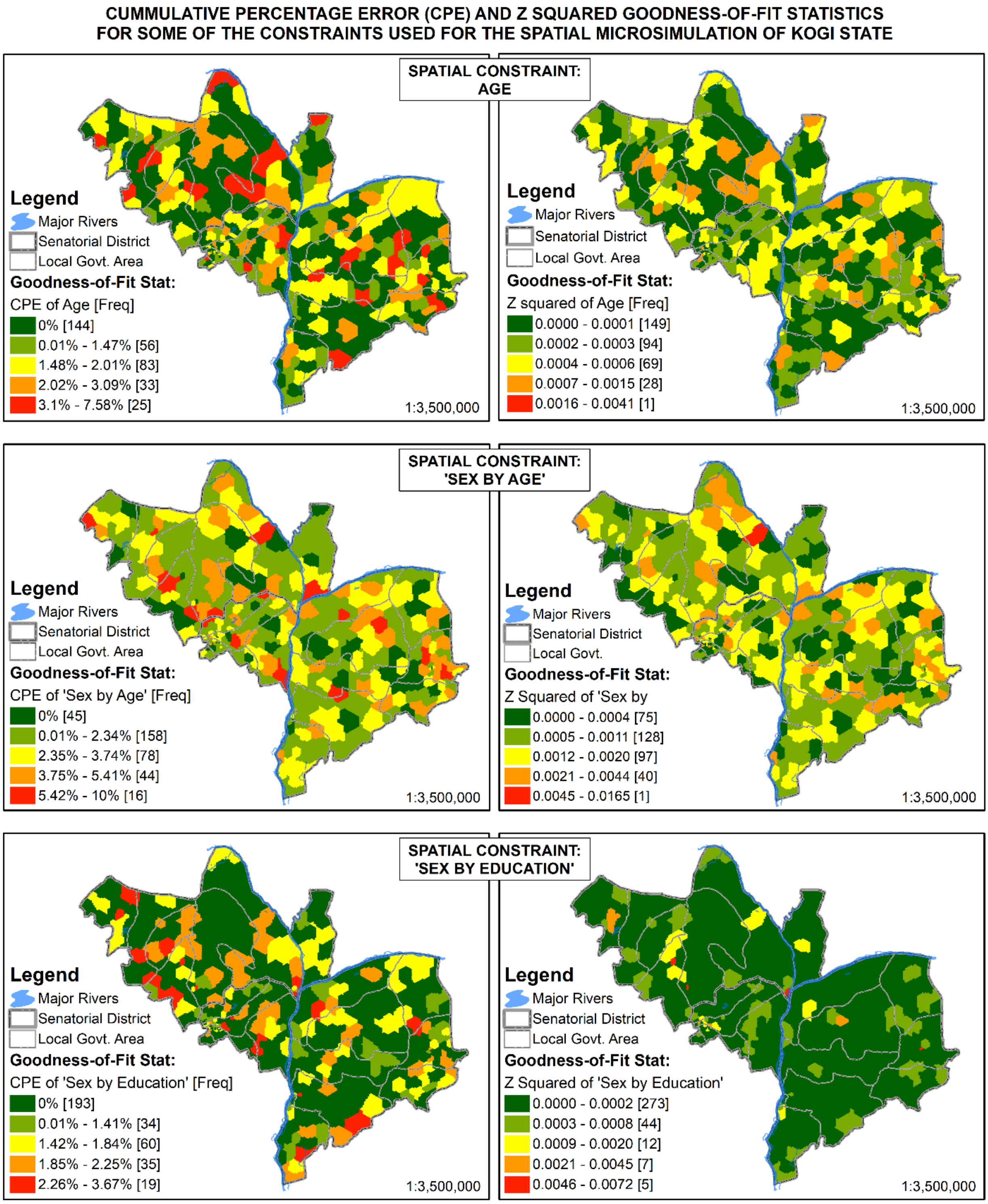


Figure A-2 Some Goodness-of-Fit statistics for three of the constraints used for the SMM of Kogi State, mapped for each synthetic small-area zone of the study area. The greener, the more accurate, while with increasing redness comes increasing relative zonal error.

A.2 Chapter 6: Choosing a Stable Distance-Decay Coefficient: Factor Analysis

A.2.1 Background

Factor analysis was used to explore the stability of the various distance-decay coefficients in this study, for values ranging from 5 – 25 minutes (O'Kelly *et al.*, 1995; Thill and Kim, 2005; Wang, 2007; Scott and Horner, 2008; Cromley and McLafferty, 2012, p. 322; Liu *et al.*, 2012). In the factor analysis, Principal Component Analysis (PCA) is used to extract the components while the Varimax method (with Kaiser Normalization) is used to rotate the component scores so as to determine what variables each component best represents. Therefore, factor analysis determined the gaussian distance-decay coefficient that accounts for most of the variations in the accessibility index of the study area. This coefficient is considered a stable distance-decay coefficient for the study area. The result of this factor analysis is presented in the next section.

A.2.2 A Stable Coefficient for the Gaussian Distance-Decay Function

Factor analyses reveal that for each of the distance-decay coefficients considered, only one factor had an eigenvalue greater than 1; therefore, 'Component 1' (in Table A-3) contains most of the variations (in the 5 distance-decay coefficients trialled) in each baseline spatial accessibility index of this study.

In addition to computing the first-factor score for each SPAI, factor analysis provides outputs on extraction communalities, total variance explained, rotated component matrix, and component score coefficient matrix. In Table A-2 is the extraction communalities for the accessibility indices derived for the 5 distance-decay coefficients of all the baseline healthcare services considered. It shows the amount of variance in each variable (i.e. the accessibility index derived for each distance-decay coefficient) that has been accounted for by the extracted components/factors. Since all the communalities in this table are high (i.e. above 70%), it implies that the extracted components/factors represent all their relevant SPAI very well, with more representation for SPAIs based on the 15- and 20-minutes coefficients (highlighted in green colour).

Table A-2 Extraction communalities for five (5) distance-decay coefficients used to calculate the E2SFCA accessibility index to select healthcare services

Variables: Distance-Decay Coefficients	Extraction Communalities							
	SBA	MHS	Malaria	Family Planning	C-Section	CHS	ANC	All
e2sfca: 5	0.724	0.723	0.729	0.732	0.711	0.718	0.728	0.736
e2sfca: 10	0.936	0.935	0.938	0.937	0.938	0.94	0.935	0.938
e2sfca: 15	0.978	0.977	0.978	0.979	0.977	0.977	0.978	0.979
e2sfca: 20	0.941	0.941	0.942	0.942	0.941	0.941	0.941	0.943
e2sfca: 25	0.855	0.857	0.862	0.86	0.863	0.862	0.859	0.861

Table A-3 shows the total variance explained by all the components/factors derived for each healthcare service SPAI. For each healthcare service accessibility (comprising the 5 SPAIs), the 'Total' column gives the amount of variance in the original variables accounted for by each component (i.e. the eigenvalue). The '% of Variance' column gives the ratio, expressed as a percentage of the variance accounted for by each component to the total variance in all the variables. For this analysis, only components with eigenvalues greater than 1 were extracted; therefore, only the first principal component is the extracted solution. Notice that for all the healthcare services considered, the first component explains about 88% of the variabilities in the original 5 distance-decay coefficients; therefore, this first component can serve as a multidimensional representative index of accessibility for all the five variables, with only a 12% loss in variability.

The rotated component matrix is presented in Table A-4, which helps a researcher to determine what variables the components represent the most. Since only one component (with eigenvalue greater than 1) was extracted in this analysis, the rotated component matrix shows the input variables to which this first component is most correlated. For the accessibility indices of all the healthcare services considered in this study, it can be seen that the 1st component is most correlated with the accessibility index derived from using 15 minutes as the distance-decay coefficient (the row highlighted in green colour). Therefore, a distance-decay coefficient of 15 minutes is a stable coefficient for analyzing spatial accessibility of baseline healthcare services in the study area and has been used in other studies (Zhu *et al.*, 2019). Chapter 6 therefore models and analyzes the SPAIs derived using a 15 minutes coefficient for the (Gaussian) distance-decay function of the bespoke ONN-G2SFCA algorithm of this thesis.

Table A-3 The total variance explained by all the components/factors derived for each variable.

Component	SBA		MHS		Malaria		Family Planning		C-Section		CHS		ANC		HC Personnel	
	Total	% of Variance	Total	% of Variance	Total	% of Variance	Total	% of Variance	Total	% of Variance	Total	% of Variance	Total	% of Variance	Total	% of Variance
1	4.434	88.688	4.433	88.658	4.449	88.973	4.45	88.998	4.43	88.602	4.438	88.762	4.44	88.809	4.456	89.119
2	0.474	9.487	0.476	9.517	0.464	9.286	0.463	9.259	0.478	9.553	0.475	9.503	0.47	9.399	0.458	9.163
3	0.082	1.639	0.082	1.638	0.078	1.565	0.079	1.575	0.084	1.689	0.078	1.561	0.08	1.609	0.077	1.537
4	0.009	0.176	0.009	0.178	0.008	0.167	0.008	0.159	0.007	0.148	0.008	0.164	0.009	0.174	0.009	0.172
5	0	0.009	0	0.01	0	0.009	0	0.009	0	0.008	0	0.009	0	0.01	0	0.009

Table A-4 Rotated component matrix

Variables: Distance-Decay Coefficients	Component 1							
	SBA	MHS	Malaria	Family Planning	C-Section	CHS	ANC	HC Personnel
E2SFCA: 5	0.851	0.85	0.854	0.856	0.843	0.848	0.853	0.858
E2SFCA: 10	0.967	0.967	0.968	0.968	0.968	0.969	0.967	0.969
E2SFCA: 15	0.989	0.989	0.989	0.989	0.988	0.988	0.989	0.989
E2SFCA: 20	0.97	0.97	0.971	0.97	0.97	0.97	0.97	0.971
E2SFCA: 25	0.925	0.926	0.928	0.928	0.929	0.929	0.927	0.928

A.3 Overview of Specialist Software Tools for Thesis Spatial Data Analytics

In this appendix, in addition to the specific software or programming tools used for accomplishing the spatial analytical operations of the quantitative aspects of the current study, other options are highlighted. Some of these software tools may be able to provide further advancement to the various research problems addressed in this thesis; therefore, they are worth exploring in subsequent works.

A.3.1 Automated Zone Designs

Whereas arbitrary (unoptimized) zones may be formed manually (or automatically) using regular geometric shapes (like squares) or by irregular shapes determined by a person's local knowledge of the area, optimized zone designs require the use of (semi-)automated zone design procedures (Burden and Steel, 2016b). (Semi-)automated zone designs rely on the use of various algorithms implemented by relevant software packages. Wang (2014b) provides a succinct overview of optimization methods for zone designs, such as the ISD method (named after the Information and Statistics Division of the Health Service in Scotland, where it was devised) (Black *et al.*, 1996), the spatial order method (Lam and Liu, 1996), and the Sheffield method (Haining *et al.*, 1994). Other robust automated zone design methods/algorithms, include the AZP (Openshaw, 1977; Openshaw and Rao, 1995; Cockings and Martin, 2005; Grady and Enander, 2009), Modified Scale–Space Clustering (MSSC) (Mu and Wang, 2008), Max-P (Duque *et al.*, 2012), Voronoi tessellations (Galvão *et al.*, 2006; Ricca *et al.*, 2008; Swift *et al.*, 2008; Novaes *et al.*, 2009; Moreno-Regidor *et al.*, 2012), Regionalization with Dynamically Constrained Agglomerative Clustering and Partitioning (REDCAP) (Guo, 2008; Guo and Wang, 2011), the Mixed-level Regionalization (MLR) (Mu *et al.*, 2015) and Maptitude for Redistricting (Caliper-Corporation, 2018). Zhao and Exeter (2016) compared four other freely available (semi-)automatic zone design tools, namely: AZTool (Martin, 1997, 2003; Cockings and Martin, 2005; Cockings *et al.*, 2011), DZ (Flowerdew *et al.*, 2007), iRedistrict redistricting (Guo and Jin, 2011; Jin, 2017), ArcGIS Districting extension and ESRI Redistricting online software (Environmental Systems Research Institute ESRI (2018), and found the ESRI's semi-automatic districting tool to be the most compatible with their design objectives. Recent automated regionalization tools have been provided as packages in the open-source R programming environment, such as 'redist' (Fifield *et al.*, 2015, 2018) and 'BARD' (Altman and McDonald, 2011).

Whereas Guo and Jin (2011) provide an excellent overview of automated districting methods, detailed reviews of solution approaches to automated zone design problems are available elsewhere (Kalcsics *et al.*, 2005; Duque *et al.*, 2007; Altman and McDonald, 2010; Ricca *et al.*, 2013; Goderbauer and Winandy, 2018). In this thesis, the AZTool software is used for the automated creation of optimized small-area analytical zones for the study area, because it is one of the most robust options that is also relatively user friendly (Ralphs and Ang, 2009; Cockings, 2013).

A.3.2 Spatial Microsimulation

Most software for Spatial Microsimulation Modelling (SMM) are based on programming languages like Java, R and Python; therefore, they require expert knowledge in computer science and programming as well as in the SMM field (Melanie *et al.*, 2017). Some specific software for Spatial MSM include LIAM2 (De Menten *et al.*, 2014), JAMSIM (Mannion *et al.*, 2012), the SMS Library for R (Kavroudakis, 2015), Flexible Modelling Framework (FMF) (Harland, 2013), OpenM++ (Open++, 2016), Micro-MaPPAS (Ballas *et al.*, 2007b), JAS-mine (Richardson and Richiardi, 2016; Richiardi and Richardson, 2017) and simSALUD (Melanie *et al.*, 2017).

A.3.3 Spatial Accessibility Analysis

Aside the E2SFCA Toolbox developed by Zhu and Wang (2015), USWFCA and the updated USW-FCA2 (Langford *et al.*, 2014, 2015) are excellent alternative software tools for performing the E2SFCA analysis in ArcGIS, which offer extensive analytical capabilities. However, since they are ArcGIS add-ins as opposed to ArcGIS tools, this limits their flexibility for use in advanced E2SFCA analysis like the current study, which implements dynamic catchments. For instance, since the tool endogenously computes the O-D matrix in the course of the E2SFCA analysis, this limits the ability to specify dynamic catchment area sizes. Further, there is limited ability to perform recursive analysis whereby some model parameters are made to change stepwise in testing the stability or sensitivity of various analytical parameters. Higgins (2019)[92] is a recent Accessibility Toolbox for R and ArcGIS that enables the visualization and customization of impedance functions and parameters. More recently, R coding has been used

[92] https://github.com/higgicd/Accessibility_Toolbox (accessed 21st March, 2020)

to perform sophisticated E2SFCA analysis after deriving relevant O-D matrices from ArcGIS[93] (Paez *et al.*, 2019, p. 36). An R Package, **SpatialAcc**[94] has many functions for performing various robust analysis of spatial accessibility (Kalogirou, 2019). There are also a python packages such as '**spatial_access 1.0.0**' (Farah *et al.*, 2019), '**Spatial Access**' (for PySal)[95](Saxon, 2019; Saxon and Snow, 2020) and 'aceso 0.1.0'[96] (Lewis, 2018) for computing various measures of spatial access, as well as other arcpy scripts.[97] Aside from the steep learning curve associated with computer programming languages, the use of these R and python environments in implementing these advanced 2SFCA algorithms offer the greatest flexibility and allows for seamless integration for other analytical steps associated with a given research project.

[93] https://github.com/paezha/Demand-and-Supply-Inflation-in-Floating-Catchment-Area-FCA-Methods- (Assessed 5th February, 2020)

[94] http://lctools.science/spatialacc/

[95] https://access.readthedocs.io/en/latest/index.html (accessed 7th February, 2020)

[96] This is a very robust python package for computing many of the advanced 2SFCA algorithms being implemented in contemporary literature, such as those discussed in Section 3.3.3.4.

[97] https://github.com/jrpaul/PhD-Tools (Assessed 05/02/2020)

Appendix B. Further Qualitative Explorations

B.1 Identity and Severity of Health Conditions

A failure to perceive healthcare need and/or the severity of a condition delays the initiation of care-seeking and/or determines the enormity of access-related disincentives that people would be willing to overcome in obtaining healthcare (Bandura, 1982; Fortney *et al.*, 2011; Ndikom and Ofi, 2012). Perceived identity and severity of illness (i.e. healthcare needs) are not only a component of 'Phase I' in the three-delays model of the current study but are also the starting point of the two other complementing conceptual frameworks of the current study, Cabieses and Bird (2014) and Levesque *et al.* (2013). Perceived identity and severity of health conditions (or the lack thereof) are therefore indicators of accessibility that are often captured under acceptability (or sociocultural) aspects of the popular conceptual frameworks of access discussed in Section 2.3.2 (Grimes *et al.*, 2011; Myers *et al.*, 2015; Bright and Kuper, 2018). In exploring popular healthcare conditions in the study area, some respondents simply remarked that there are too many ailments in their locality to be mentioned. For instance:

> *"…people suffer too many health challenges." [Ugbabo]; "if you ask us to mention the sicknesses here, it would be difficult because we all have different types of sicknesses we are faced with…" [Ochi]; "we have numerous diseases affecting us in this locality…" [Uvete]; "we suffer a variety of ailments here" [Aloko].*

Not only does this suggest a preponderance of healthcare needs in the study area, but it also shows that some of these conditions are of a nature that is undiscernible by laypeople, requiring diagnosis by relevant medical practitioners.

In highlighting recognized sickness types, some health conditions are more common or unique to some demographic groups, whereas others have no demographic ascription. Women and children are the main demographic groups with peculiar healthcare needs, as well as the aged/elderly. Most gender-specific healthcare needs associated with women in the study area are pregnancy-related, as expected. These can be categorized as Maternal Health Services (MHS), which include antenatal, intrapartum, and postnatal care, some of which appear in the word cloud of Figure B-1B. Unlike the administration of drugs, MHS typically necessitates multiple visits to healthcare facilities as well as the need for specialized equipment like scanners, including a requirement for specialist medical procedures like surgery (caesarean section). It is therefore not surprising that several literature reviews on healthcare access

Figure B-1 Word clouds showing: (A) words frequent associated with illness types and (B) pregnancy-related healthcare needs.

focus on MHS (Hill *et al.*, 2013; Wilson *et al.*, 2013; Kyei-Nimakoh *et al.*, 2017; Geleto *et al.*, 2018; Sumankuuro *et al.*, 2018). The spatial accessibility indices (SPAIs) of pregnancy-related services, such as Maternal Health Service (MHS), Skilled Birth Attendants (SBA), Antenatal Care (ANC) and Caesarean Section (CS), which are shown in Figure 6-14 (C, D, E and F), are therefore of crucial importance. Aside from these, other perceived female-related health conditions in the study area are rheumatism and 'spiritual husband'[98]. Children were reported to mostly suffer from: anaemia, measles, convulsion, worms, diarrhea, vomiting, malaria, and meningitis, some of which can be prevented by appropriate vaccination. Indeed, treatment for most of these conditions can be categorized as Child Health Services (CHS), whose SPAI is depicted in Figure 6-14A. The elderly are prone to stroke, high blood pressure, diabetes, and sight problems. The Essential Healthcare Package (EHP) of PHC delivery in the study area does not cover needed healthcare services for all of these conditions (especially the healthcare needs of the elderly) (Chapman *et al.*, 2017; Federal Ministry of Health (FMoH), 2018, p. 13; Watkins *et al.*, 2018); therefore, travel to other secondary and tertiary facilities for these services becomes inevitable as discussed further in Section 7.3.

[98] 'Spiritual Husband' is a perceived health condition in the study area which is of a spiritual nature. Here, a single female of marriageable age is considered to be experiencing a condition of involuntary and unconscious marriage to a male spirit, the spiritual husband, who in turn prevents her from being married in reality. By virtue of being spiritually married, it is mythically assumed that she is not marriageable unless her divorce or exorcism from the spiritual husband is enforced by relevant TCAM practitioners.

Perceived healthcare needs that were of a population-wide nature, being that they were not ascribed to any specific demographic group in the study area include: malaria, fever, typhoid, stomach ache, chest pain, headache, back pain, waist pain, cough, cholera, appendicitis, hernia, diabetes, high blood pressure, maladies from domestic or road accidents (like dislocations, fractures, bleeding, injuries, bruises etc), measles, mental illness, epilepsy, spiritual problems, anaemia (shortage of blood), ulcer, arthritis, HIV, pile, and leprosy. The word cloud of Figure B-1A suggests that a good number of times, these health conditions were referenced with the general terms like 'disease' or 'sickness'; however, when specific health conditions were mentioned, 'malaria', 'typhoid' and 'fever' were the most recurrent. On the one hand, this foregrounds the salience of accessibility to enhanced malaria treatment therapy, Artemisinin-based Combination Therapy (ACT). On the other hand, the need to be attentive to the treatment of typhoid fever is underscored, since it is not one of the baseline healthcare conditions that is receiving priority attention in the country. Among other things, this diversity of health conditions shows that some of these illness types are outside the remits of PHC, making transport to secondary or tertiary healthcare facilities inevitable. Respondents also admitted not knowing the identity of some sickness types: *"Sometimes, people contract sicknesses we are not even aware of its nature"* [Aloko]. Furthermore, lay people in the study area may not be aware of potential health conditions whose services could be needed (Ndikom and Ofi, 2012).

Associated with these illness types are perceived severity, which determines the urgency as well as the access-related disutility that patients are willing to overcome in seeking care (Thaddeus and Maine, 1994, p. 1096). Physical manifestations of the pain or discomfort that a patient seems to be experiencing from a health condition often determine its perceived severity. This could be in the form of groanings or other forms of physical debilitations. Conditions like bleeding, fracture or labour are typically subconsciously rated as severe conditions. For instance:

> *"When I went to one of the hospitals for delivery, I met only one nurse there, she saw me bleeding, yet she was asking for my card, it was an elderly woman who shouted at her to attend to me, it is really frustrating." [Uvete]*
>
> *"The pain of labour is unimaginable; it can lead to instant death" [Ochi].*
>
> *"…in case of an accident, when someone has dislocation or broken bones…" [Aiyetoro-Kiri]*

These severity connotations are often narrated with phrases like:

> *"if the condition of the patient is very critical…", "…somebody that is sick seriously may not be able to climb bike…" [Aiyetoro-Kiri]; "if the person's condition is really bad…", "when someone is sick and it is really critical" [Ike-Bunu]; "there is a very dangerous disease in town now…", "…accident victims who are at the point of death, losing blood.", "maybe your own condition is more critical than the other person…" [Eba]; "… if the person is very sick", "…especially for serious illnesses" [Aloko]; "…which makes the typhoid we suffer here very strong" [Ugbabo]; "…because most times their condition is serious" [Ochi].*

Although these phrases may be products of the translators' lexicon, they all point to the fact that respondents all over the study area are conscious of variations in the severity of diverse illness types, which informs their health-seeking behaviours.

B.2 Causal Attribution and Curability of Health Conditions

With few exceptions, the causes of health conditions did not feature much in group discussions, especially because it was not one of the prompts for the group conversations. This also suggests that either these are often taken for granted or left for medical diagnosis in cases that are not apparent. In all the four (4) wards visited, road accidents are responsible for some serious health conditions (Adewole *et al.*, 2012; Elbashir *et al.*, 2014), especially joint dislocations, bone fracture, and painful injuries, all of which are usually severe as discussed in Appendix B.1. These accidents are often associated with the use of motorcycles (i.e. *okada*) for transportation.

> *"… my wife had an accident while travelling on a motorcycle and she used her chest to hit the ground such that she even fainted"* [Aiyetoro-Kiri]
>
> *"Last year, my child had an accident, I paid the sum of ₦220,000 in Anyigba for a surgery to be carried out on him..."* [Aloko]

Not only does this suggest that *okada* is a popular transportation medium in these eMUAs, it shows that the transportation process itself is a very risky activity that contributes to health conditions in these already disadvantaged localities (Thomson, 2005; Jammeh *et al.*, 2011). These travel-related accidents are also likely to be rampant because being the most popular transportation medium in eMUAs, *okadas* are used over longer distances than they are appropriate for. This is compounded by the fact that the road infrastructure in these places is very poor, being very rough and sometimes sandy as well (Kawuwa *et al.*, 2007; Adewole *et* *al.*, 2012; Bhopal *et al.*, 2013), as discussed further in Section 7.3.3. Consequently, improving the quality of transportation infrastructure in eMUAs of the study area will not only enhance the accessibility of PHC facilities but will also reduce the incidence of transport-related health conditions resulting from road accidents that are rampant in these contexts.

Hygiene and environmental cleanliness feature amongst recognized lay causes of some health conditions in the study area. In this regard, respondents at Uvete noted a need to ensure a sanitary environment devoid of bushes and stagnant water. By so doing, mosquitoes are deprived of potential breeding sites, thereby mitigating malaria incidences in their locality. They remarked that: "*We need to collectively make our environment clean and make provision for the flow of stagnant water and for the environment to be sanitized every week*" [Uvete]. Contaminated foods resulting from poor hygiene as well as bad drinking water are known to cause illnesses. Buttressing the need for good hygiene, a respondent at Uvete explained that: "*We are supposed to take care of our food, we should always wash our dirty dishes and parboil our foods…*". The preponderance of typhoid in the study area is attributed to a lack of potable water. In this regard, a respondent at Ugbabo remarked that "*malaria and typhoid are common here, because of the kind of water we have. Our water is not clean. We drink stream water which makes the typhoid we suffer here very strong.*" [Ugbabo]. The double effect of a lack of potable water on the health difficulties at eMUAs is hereby underscored, in that it not only disincentivizes healthcare personnel from being willing to reside in these localities, it also creates health conditions that require medical attention, as discussed further in Section 7.3.4.

Whereas poverty is also implicated as the overall cause of illnesses, the rigorous manual labour associated with farming methods employed in eMUAs, most of which are agrarian rural communities, is closely associated with this. It is interesting that lay respondents recognize the overarching effect of poverty on their health, even though they may not realize the extent to which its effects are pervasive. When asked about the causes of sicknesses and a general lack of wellbeing at Ofabo, the response was unanimous: *"Money! Lack of money; without money, you cannot access good healthcare"* [Ofabo]. One consequence of poverty in rural localities is that males (and sometimes females) have to remain engaged in rigorous manual farming practices even though they are aware of the potential negative effects on their health. This was foregrounded by participants who stated that "*we are mostly farmers here and our farming method is manual labour which is often very rigorous, it causes waist pain and makes* *us sick*" [Ochi]. Speaking further about the rigour of manual farming practices, women particularly explained that:

> "*At our age, it is too much hard work for us to work with cutlass and hoes, and it takes a lot of strength. It is making us age quickly and highly prone to sicknesses, softer jobs like trading that do not require so much of physical strength is better for us*" [Aloko].

Rural poverty means that farmers in these localities are not able to adopt modern farming practices, which are often expensive, even when they are aware of their potential benefits. In their words:

> *"We are mostly farmers here; we do not have any other occupation. We will appreciate it if the government can help us with fertilizers, chemicals and those things that can help boost our productivity. We are very hardworking, before this meeting, we had all gone to the farm to work earlier today.", "We need tractors." "If we have those chemical pumps, our productivity would be higher…"* [Aloko]

Consequently, it is not surprising that the need for empowerment through poverty alleviation interventions was buttressed by many group discussions, as explained further in Appendix B.3. In this regard, poverty alleviation serves not only to prevent sicknesses but through the resulting socioeconomic improvements from these interventions, rural dwellers become more capable of meeting their healthcare needs whenever they arise. This is well theorized by the capability approach (Kinghorn, 2015; Karimi *et al.*, 2016; Clark *et al.*, 2019). The effects of poverty on health conditions are very telling in that it both causes adverse health conditions and at the same time, makes sick patients incapable of affording the various financial costs associated with obtaining needed healthcare, as discussed further in Section 7.3.5.

In terms of perceptions of the curability or controllability of various health conditions, western medicine is preferred for treating the majority of common health conditions discussed in Appendix B.1. Remarking on their reason for preferring western medicine to TCAM (Andrews *et al.*, 2010), a respondent at Ugbabo explained that:

> *"We believe that more knowledge and expertise is put into developing orthodox medicine and medical service. Science and technology make orthodox medicine more efficient and preferable."* [Ugbabo].

Similar sentiments were expressed in other group discussions, which also extolled the biomedical treatment practice of running medical diagnosis (such as laboratory tests or scans) to ascertain the cause of an ailment before commencing treatments, unlike TCAM. A major caveat to this preference is that there are select health conditions that are generally known to require TCAM treatments in the study area. These health conditions are perceived to be better treated by TCAM than western medicine (Cannoodt *et al.*, 2012; Worku *et al.*, 2013; Aborigo *et al.*, 2014; Wesson *et al.*, 2015). This is especially the case for illness types that are attributed to spiritual causes (Westerlund, 2012, p. 444; Echoka *et al.*, 2014), which tend to be oblivious to biomedical diagnosis and treatments (in western medical facilities). These spiritual health conditions are often weird and unlikely to make sense to biomedical medical practitioners. Consequently, relevant TCAM treatment options (such as Traditional Birth Attendants or Native/Witch Doctors) are consulted for such health conditions (Combs Thorsen *et al.*, 2012; Liambila and Kuria, 2014), as suggested by the following narrative:

> *"Some illnesses are better treated by traditionalist than in western hospitals". "A lady I know was being disturbed by a spiritual husband and was taken to the mosque for prayers; she became normal after the prayers."* [Eba]

Spiritually-induced stomach aches were recorded at Ochi and Uvete, which were treated by a native doctor and an Islamic prayer house, respectively. Furthermore, insomnia, exceptionally stubborn children, mental illness, epilepsy and other spiritual problems were taken to prayer houses for prayers and deliverance, especially at Uvete.

Among other things, these narratives suggest that in seeking healthcare, people at eMUAs tend to sometimes use TCAM as complements of western medicine treatments (King *et al.*, 2009; Campbell-Hall *et al.*, 2010; Madiba, 2010). For example, at Uvete, a health condition (i.e. stomach ache) that previously evaded curability by western medicine became treatable by the same western treatment after the patient's prior engagement with TCAM (for prayers). Indeed, from first-hand experience, the researcher is aware of the use of prayers as an important prelude to western medical treatment. Similarly, in the study area, many medical personnel in western healthcare facilities also say prayers before embarking on the diagnosis or treatment of patients. This is corroborated by respondents who noted that *"…most doctors now, those who are Christians among them go on their knees to pray before work, while those who are traditional among them consult oracles before work…"* [Aiyetoro-Kiri]. This ritual seems to increase patients' confidence in such medical personnel. The foregoing narratives also suggest a preponderance of spiritually caused illnesses amongst females compared to males. This supports studies that suggest that females are more vulnerable to psychological conditions than males (McLean *et al.*, 2011; Muntaner *et al.*, 2013; Cockerham, 2014a).

Furthermore, the type of TCAM patronized is a function of the local socio-cultural context in that the dominant local faith beliefs are likely to be consulted for the provision of the needed cure. For instance, most perceived spiritually-induced cases at Uvete and Eba were taken to Mosques for Islamic prayers since the majority of people in Kogi Central senatorial district are Muslims, as explained in Section 3.4.1.

Furthermore, a few health conditions which may not be ascribed to spiritual causes are often taken to TCAM practitioners because they are either perceived to offer more acceptable treatment options or are cheaper (and therefore more affordable). Whereas the effects of affordability on the patronage of TCAM are discussed in Section 7.3.5, the current section focusses on the acceptability and efficacy of curability options between orthodox and TCAM treatments. Of particular note in this regard are joint dislocations or bone fractures, which often result from transportation-related accidents. On these, some respondents remarked that:

> *"My late father [a native doctor] was called upon on different occasions, to administer his own form of treatment to people with bone fracture, stroke and spiritual problems." "Some people left the hospital for my dad's place and they were treated. Some with strokes who had stayed in the hospital for a long time were also brought to him for treatment and they were treated."* [Ochi]

> *"For example, when someone breaks/fractures (or dislocates the joints of) a leg, I have a relative who is a doctor and doesn't believe broken legs can be treated at the hospital except at traditional healing houses and when such a case is taken there, they will be healed. If they go to the hospital, they will be amputated and given crutches. There are cases like that, including people living around us, and doctors understand and know that there are some cases they can't handle in hospitals, but if taken to traditional healing houses, it would be handled. Mostly broken legs, I think it is treated more efficiently by traditional healers than by orthodox medicine. Instead of putting iron in broken bones, traditional bone setting is more efficient than all that."* [Ochi]

> *"…in case of an accident, when someone has dislocation or broken bones, even in the city, if they take it to big hospitals, in the process of treating it, it might start decaying and the doctor will have no option again than amputating the leg, they will cut it and*

give the person a walking stick, but we see some traditionalist that can rearrange it in their own way and the leg will be functioning without amputation…" [Aiyetoro-Kiri]

Thus, patients' aversion to amputation, which often results from western treatment options, informs their preference for TCAM, which seldom warrants amputation. The perception that TCAM offers more effective treatment for some health conditions which may not necessarily be spiritually-induced (such as stroke, epilepsy and mental health conditions) also inspires a preference for TCAM. Nevertheless, the inability of western medical services to provide both effective and acceptable treatment options could be a result of Nigeria's generally low level of development, including in areas of medical science and technology. Had available orthodox medicine been able to provide efficient treatment solutions, participants are likely to also prefer them to TCAM options for the treatment of these health conditions, which are not expressly ascribed to spiritual causes. As with other health conditions, a recourse to TCAM would have been considered only after having made failed/unsuccessful attempts at western medications.

In the event of seeking TCAM, the type of TCAM service patronized is a function of the sociocultural context. On a case-by-case basis, the self-system of a patient is mediated by lay referral networks (all of which are encapsulated in the sociocultural context) to determine when and what type of TCAM practitioner to patronize. These dynamics are illustrated in Figure 7-2. Once a decision to patronize TCAM is reached, Christians, Muslims or traditional practitioners are likely to patronize relevant TCAM that are congruent with their respective faith/religious belief systems. Furthermore, the ubiquity of poor quality western medical diagnosis and treatment options in Nigeria means that patients are not always able to obtain the best biomedical treatment options for illnesses. As such, the failure of available western treatments to offer effective cures motivates patients to begin to suspect/speculate that a given ailment that had evaded western cures is diabolic (i.e. of a spiritual cause). Thus, a resort to TCAM is partly motivated by the inability of accessible western healthcare facilities to offer effective treatment options that are acceptable because of their being out of touch with state-of-the-art medical technology and medications. It is therefore not surprising that many rich and/or highly placed public officials in Nigeria, some of whom are complicit in the neglect and resultant poor quality of western healthcare in the country, are now infamous for patronizing healthcare facilities abroad, even for mundane illnesses like headaches and fever (FMoH, 2016, p. 88).

In sum, despite the overwhelming acceptance of and preference for western biomedical medical services in the study area, patients are sometimes constrained to patronize TCAM for the following reasons: (1) they are more affordable than western medicine, being almost free; (2) some types of health conditions are attributed to diabolic/spiritual influences; therefore, not only are they undiscernible by western diagnosis, they cannot be treated by the same (without some preluding spiritual interventions); (3) the ubiquity of poor quality western medical services in Nigeria means that they are sometimes unable to provide effective and acceptable treatment options for some health conditions. This inability to offer effective and acceptable treatment for some relatively common health conditions (such as stroke, epilepsy and joint dislocation and bone fracture) motivates patients to seek care at TCAM providers. The discussions in the current and preceding appendix is the basis for the synthesis of lay perceptions of health conditions in eMUAs provided in Section 7.2. This also serves as a prelude to Section 7.3 which turns to experiential indicators of perceived accessibility.

B.3 Desired Remedial Interventions

This section addresses the third research question of the subjective aspects of this thesis: What interventions do participants crave, and why? This is in tandem with the values of the current thesis, which is grounded in egalitarian theories of distributive justice and universal rights to primary healthcare. These necessitate a consideration of the interest and expectations of disadvantaged population groups as a means of appropriately empowering and/or emancipating them (Gesler and Kearns, 2002, p. 159).

When asked what type of help participants require in order the alleviate their healthcare-related sufferings, the main response was that a good hospital should be sited in their community (Levine *et al.*, 2007). At localities with existing hospitals that are either non-functional or sub-standard, participants want a rejuvenation or upgrade (Urassa *et al.*, 1997; Afsana and Rashid, 2001). Expected upgrades include the provision of required equipment and supplies which are lacking, including drugs and necessary supplies of syringes and other requisites. Where available, the size or capacity of extant hospitals should also be increased by creating more wards, providing more hospital beds and employing more personnel. This would help forestall long waiting times at their currently insufficient hospitals or having to cover long distances in search of care elsewhere, saving them both time and money as a result. Being itself a social amenity, not only would good healthcare facilities help in the development of their various communities, it would also create some employment opportunities for them. To this effect, respondents made the following remarks:

> "*if we have government hospital in this community, the problem of transporting sick people will not be there for us anymore and that two hours of transportation is even enough to treat a sick patient, so if we have government hospital here, it will help us a lot. …this hospital will also create jobs for the people of the community and contribute to the development of the community*". [Aiyetoro-Kiri]

The need to complement the building (or upgrade) of a hospital with employment or redeployment of qualified healthcare personnel was buttressed in all fieldwork sites (Levine *et al.*, 2007; Bronsard *et al.*, 2008). In this regard, participants want the government to employ more staff, giving priority to the indigenes of their community. They explained that instead of having healthcare workers who are outsiders, natives who are familiar with the local environment and people would be better placed to address their healthcare needs at hospitals. In this regard, participants at Uvete stated that:

> "*the government needs to employ competent hands from our communities here instead of hiring outsiders all the time. Our own people here will know how to handle some of the health challenges we face better, due to their familiarity with the environment and people*". [Uvete]

It is noteworthy that in addition to the better treatment of patients, personnel who are natives of their respective communities are likely to be more willing to reside in their respective rural service locations than non-natives (Serneels *et al.*, 2010; Johnson *et al.*, 2011; Snow *et al.*, 2011). Nevertheless, there is a tendency that this comes with its own challenges, such as favouritism and nepotism mentioned in Section 7.3.4. Furthermore, it is not always the case that there are sufficient indigenous medical personnel from each community to man their respective healthcare facilities. This may therefore warrant a balance between having native and non-native healthcare personnel employed at various facilities for checks and balances. Proper management of healthcare personnel is also necessary, as discussed further.

In addition to a need for prompt payment of workers' salaries, participants expressed a desire for better administration of hospitals in order to avoid many of the personnel-related disincentives to healthcare accessibility recorded in Section 7.3.4. The concerns raised include:

disrespect for patients, absenteeism or neglect of duty, fraud or sharp practices as well as poor services. At Uvete, participants stated that:

> "*…we want the government to caution health workers on the need to eschew exorbitant charges because things are very hard at the moment. Secondly, nurses should stop shouting at hospital patients. These patients are sick and it's not our wish to be sick*" [Uvete]

The need to enhance the quality of sociocultural aspects of healthcare in rural localities (such as personnel attitudes) through improved management/administrative practices have become increasingly relevant in recent times (D'Ambruoso *et al.*, 2005; Kruk *et al.*, 2014; Afulani and Moyer, 2019). In a similar vein, a need for proper monitoring or supervision of public hospitals was also foregrounded (Bosch-Capblanch and Garner, 2008; Renggli *et al.*, 2018; Francetic *et al.*, 2019). The following statements vividly explain these concerns:

> "*after making provisions for all the drugs, injections and other facilities, the government should set up a committee that will be paying hospitals impromptu visits to know if truly hospital staffs are doing their job properly…*
>
> *…there is a need for the government to monitor these drugs. The prices, quantities and quality of drugs given to the hospital should be constantly checked. Are they being given to patients? All these need to be put in place to ensure it gets to the right people at the right time*." [Eba]

This is congruent with a need to eradicate corruption by improving accountability and transparency in the administration of public healthcare facilities (Afsana, 2004). This also implies that problems of inaccessibility in the study area are far more intricate than the mere provision of appropriate transportation infrastructure and medical facilities, even though this would be very helpful.

While the foregoing desired interventions are necessary conditions for enhanced healthcare availability in their respective localities, participants were aware that the sole intervention of siting a good hospital would not be sufficient for actualizing healthcare accessibility in their community. This is because healthcare personnel would not be willing to reside in these eMUAs since they are in dire lack of basic social amenities (Kruk *et al.*, 2010; Snow *et al.*, 2011). A holistic solution was therefore proposed, which includes the provision of social amenities that are not only needed for the effective functioning of hospitals, but will also make healthcare personnel willing to reside in these eMUAs (Darkwa *et al.*, 2015). In this light, participants noted that:

> "*First, the government should help us to establish a hospital; however, doctors will not want to stay if the mobile communication network is poor. NGOs can help us to create means of communication, like good roads and mobile communication networks. Commercial actives should be provided for us here, such as banks, for easy transactions and payment of hospital bills. This will reduce our necessity for traveling and it will ease the job of doctors and encourage them to stay*". [Aiyetoro-Kiri]

In terms of which specific remedial interventions to prioritize in ameliorating healthcare difficulties in these eMUAs, there seems to be some contention about which intervention should come first between the establishment of good hospitals and the provision of good roads. For instance, participants at Aloko remarked that:

> "*there is a doctor we usually call; he comes from Anyigba. Because of the state of the road; sometimes, before he gets here, the patient may have died. Hence, is it not better we get the road first?*" [Aloko]

On the contrary, it was explained that health is of utmost importance to the community; therefore, the establishment of a healthcare facility should be prioritized. According to them, it is unlikely that the government would be able to simultaneously provide good healthcare facilities and all the other basic social amenities that are currently lacking. They remark:

> "*We cannot wait for the government to build roads, provide electricity, water, telecommunication network, etc before building a hospital for us. That will take long, and before then, many people might have died due to a lack of immediate medical attention. We need all the amenities, but we are in dire need of a good hospital right now. Let it come before the others*". [Aloko]

The foregoing suggests palpable tensions concerning which intervention to prioritize, since, on the one hand, repairing roads does not resolve all the transport-related disincentives (as discussed in Section 7.3.3). The provision of a good hospital (with personnel) is also likely to prove abortive if healthcare personnel are unwilling to reside in such remote rural localities, which typically lack basic social amenities. This is evident because extant well-built 'model' primary healthcare facilities at both Oganenigu and Ayetoro-Kiri wards are yet unfunctional (see Figure 7-4). The need to prioritize transportation infrastructure is supported by some participants who said that:

> "*Firstly, is the issue of our road, if the government can help us to construct a good road, to bring government hospital here will not be a problem*" [Aiyetoro-Kiri]
>
> *"…if the hospital is in order [referring to the non-functional hospital in Figure 7-4] and the road is bad, there will not be access to get to the hospital with ease. So, we need a good road".* [Ike-Bunu]

Therefore, this research supports the argument that the provision of good roads should receive priority attention in alleviating healthcare accessibility challenges in eMUAs of the study area (Malhotra *et al.*, 2005; Levine *et al.*, 2007). Roads would bolster the overall economy of these currently excluded localities by serving several other purposes beyond (or in addition to) the narrow precincts of improving healthcare accessibility (Datta, 2012; Casaburi *et al.*, 2013; Ali *et al.*, 2014). Unlike the provision of hospitals, the provision of good roads tends to alleviate a larger chunk of transport-related disincentives and indeed serves as a veritable catalyst/facilitator for sustainable healthcare accessibility. The same cannot be said of the establishment of a good hospital since there is scanty evidence to support the notion that it is capable of catalyzing/attracting the establishment of other social facilities and amenities in disadvantaged communities. Notice also that it is not efficient to site a good hospital in every single community since there is a service threshold requirement for healthcare facilities (Litaker and Love, 2005, p. 185). This implies that a need for travel is inevitable, but this would pose negligible disutility of healthcare if an optimal constellation of healthcare facilities is being established based on an already enhanced transportation network. Indeed, because PHC facilities are unlikely to be able to handle every healthcare need, there will still be a need to travel long distances in seeking care at tertiary or specialist hospitals elsewhere when there is a referral. However, with the local availability of functional PHC services in various localities, there will be far fewer instances of such need to travel elsewhere for health-related reasons.

In view of ravaging poverty in eMUAs, participants are keen on receiving subsidies and other forms of palliatives from the government. This includes the provision of amenities to support their economic activities, which include farming and trading. In their words:

> "*I think the most important among this list is empowerment because if one is empowered, such would be able to take care of his medical needs*". [Ochi]

"Yes, even the women, we do not get any form of help from the government, we exert a lot of physical strength while farming. If we can get help from the government in terms of soft loans for trading instead of farming, we would appreciate it". [Aloko]

Not only would this help minimize the incidence of poverty-related ailments in the study area, it would also make participants more capable of affording medical bills whenever there is a need. In this regard, farmers require various forms of support that are capable of boosting their agricultural productivity. These include fertilizers and chemicals (like pesticides and weedicides), chemical pumps, farm implements like cutlasses and hoes, improved seedlings, as well as tractors. On the other hand, traders are desirous of soft loans, which would serve as capital to increase their stock in trade. Indeed, even though participants may not have construed their desire for empowerment in its broad sense, in LMICs like the study area, it has been argued that healthcare access is synonymous with empowerment to use healthcare services (Thiede *et al.*, 2007; McIntyre *et al.*, 2009).

On the expected source of help, it is well-recognized that the provision of basic public amenities like hospitals is a responsibility of the government. Therefore, a majority of participants expect the government to fulfil this obligation. Nevertheless, they are happy to receive help from whoever or wherever it may come from. This comes on the heels of a profound distrust of the current political administration to meet their healthcare needs and a consequent resort to fatalism instead. This is expressed in the following narratives:

"I will suggest we continue to pray to God to help us because even our government of today considers their own interest more than the people. They are only after how they will enrich themselves." [Eba]

"I think our only hope is on NGOs because this government has lost its track (laughs). We pray to God that compassionate people who have the means come to our aide. These days, people mostly depend on associations or cooperative societies, not on the government. God will help us; we will survive." [Ochi]

"…if we sit here and wait for this government, nothing will get done, except we pray that this present government goes before we see any of these things. We have more faith in private organizations than the government. If we wait for this government, we will die in poverty…" [Ochi]

From the foregoing narratives, it is apparent that despite a recognition that the government is responsible for providing basic social amenities for communities, including healthcare facilities, participants are very sceptical of the government's interest in ensuring their welfare. Consequently, in addition to a sense of fatalism, participants welcome help from any willing source, such as Charities and NGOs.

Appendix C. Documentation for Qualitative Fieldwork

C.1 Fieldwork Risk Assessment Form

School of Geography Politics and Sociology Travel Risk Assessment

Travelling without appropriate risk assessment may prejudice subsequent insurance claims

One copy of your signed RA must be left with the GPS School Safety Officer.

Send risk assessment to:physgeog-technicians@ncl.ac.uk

Traveller

Name	Student Number	School	Unit	Telephone mobile & landline	E-mail University and/or personal	Next of Kin (Name and contact details)
Eleojo Abubakar	150622769	GPS	Geography	+447917138815 +2348056894358	e.o.abubakar2@ncl.ac.uk info4ele@yahoo.com	Ugbede Abubakar +2347066135898

Add more rows for additional travellers

Project or Module

Title	Summary (Please provide a summary of your work activity/ project/ research which requires you to travel)
Doctoral Research Theme: The Socio-Spatial Coverage and Inequalities of Healthcare Services in Nigeria	Without appropriate interventions, localities with the most healthcare needs often have the least provision of essential healthcare services and vice versa. Furthermore, planned health service expansions in developing countries often favour the socioeconomic well-off before reaching the deprived majority. This phenomenon is well explained by the inverse-care law (Tudor-Hart 1971) and the inverse-equity hypothesis (Victora et al, 2000) respectively. Health geographers are interested in studying this mal-distribution of healthcare, with a view to proffering empirical evidence-based solutions. This study is one of such efforts, aimed at ensuring a better coverage of essential healthcare services, such that the need or demand for essential healthcare services is matched with proportionate supply while prioritizing the healthcare needs of socioeconomically disadvantaged groups. Overall, this is an effort toward meeting the Universal Health Coverage (UHC) target of the Sustainable Development Goals (SDG) (i.e. SDG 3, target 8). Therefore, there is a need to collect relevant qualitative primary data from the study area (Kogi State, Nigeria). To this end, focus groups will be conducted in various local communities with the aim of investigating barriers to healthcare utilization particularly in cases where available or planned health facilities are likely to be underutilized (or neglected) by needy population. By so doing, the researcher hopes to learn of the participants' first-hand experiences, opinions, feelings and knowledge – of existing healthcare services within their reach and how potential service reconfiguration and/or expansion could influence these perceptions. This study is also interested in knowing if and how a person's circumstances (in terms of their demography and socioeconomic status) influences their decision and ability to obtain the necessary healthcare.

Emergency Contacts

Insurance insurance@ncl.ac.uk Tel: +44 (0) 191 208 6520	• **Emergency claims – Chubb Assistance: +44 (0) 207 895 3364** (policy numbers: 64811698 – UG students and 64811697 – PG students and staff)
Selective Travel Management	Routine - 028 9044 2071 (8.30am- 6pm) ncl@selective-travel.co.uk Emergency - +44 7720 593700
British Embassy Please note for staff/ students who are not UK nationals please enter your own Government embassies in this section.	Nigeria High Commission 9, Northumberland Avenue London WC2N 5BX United Kingdom
In Country Emergency Services	911
In country local contact during trip (Address/ e-mail/ mobile/ landline)	Dr Francis O. Atanu Department of Biochemistry Faculty of Natural Sciences Kogi State University, Anyigba PMB 1008, Anyigba, Kogi State. NIGERIA Mobile: +2348064310495 Email: atanufo@gmail.com
Newcastle University Contact • PI/Module Leader/ Line manager/ supervising academic/office • Security +44 (0) 191 208 6817 (24 hours) security.control@ncl.ac.uk	Postgraduate Research Office School of Geography, Politics and Sociology Newcastle University, UK gps.pgr@newcastle.ac.uk

Foreign and Commonwealth Office (FCO) Travel Advice

What is the FCO travel advice for your destination(s)? For trips to more than one country please tick all the levels of travel advice which apply for all the countries you are planning to visit.

FCO advice categories	Copy of web link to FCO travel advice	Destination Country Please name all destination countries
☐ Advise against all travel (red) No staff or students are permitted to travel to these destinations.		
☒ Advise against all but essential travel (amber/ orange) UG students are not permitted to travel. PG students and staff may travel but the risk assessment **must** be approved by the Pro Vice Chancellor.	https://www.gov.uk/foreign-travel-advice/nigeria	Nigeria
☐ See FCO travel advice before travelling (green). Students and staff may travel having regard to the FCO travel advice		

Itinerary

✈ Departing Flight			
Date	From (country & city)	Flight Number	To (country & city)
26/02/2018	Newcastle, UK	AF 1559	Paris, France
26/02/2018	Paris, France	AF 0514	Abuja, Nigeria

Add additional lines as necessary

Accommodation (hotels/ apartments/ hostels etc.)

Check in date	Check out date	Name & address	Website
		M & G Guest House, Along Anyigba-Lokoja Express Way, Anyigba, Nigeria	*No hotel in Anyigba is on booking.com neither do they have websites*
		Reverton Hotel, 1-5 Kunama Crescent, Behind Kogi Hotels. GRA, Lokoja, Nigeria	https://www.booking.com/hotel/ng/reverton.en-gb.html
		Lisa Palms hotel, 1 okene road obajana junction, Kabba, Nigeria	*No hotel in Kabba is on booking.com neither do they have websites*

If accommodation changes whilst 'in country' please update risk assessment & share with School/ Institute ASAP

Meetings and Events

Date(s)	Meeting/ event description	Venue/ location/ telephone
Various dates	Conduct at least 6 focus group discussions relevant to my research theme.	Various localities in Kogi State, Nigeria, including: Ogane Inigu, Ogbonicha, Aiyetoro-Kiri, and Nagazi Farm Centre.

Add additional lines as necessary

Return Flight

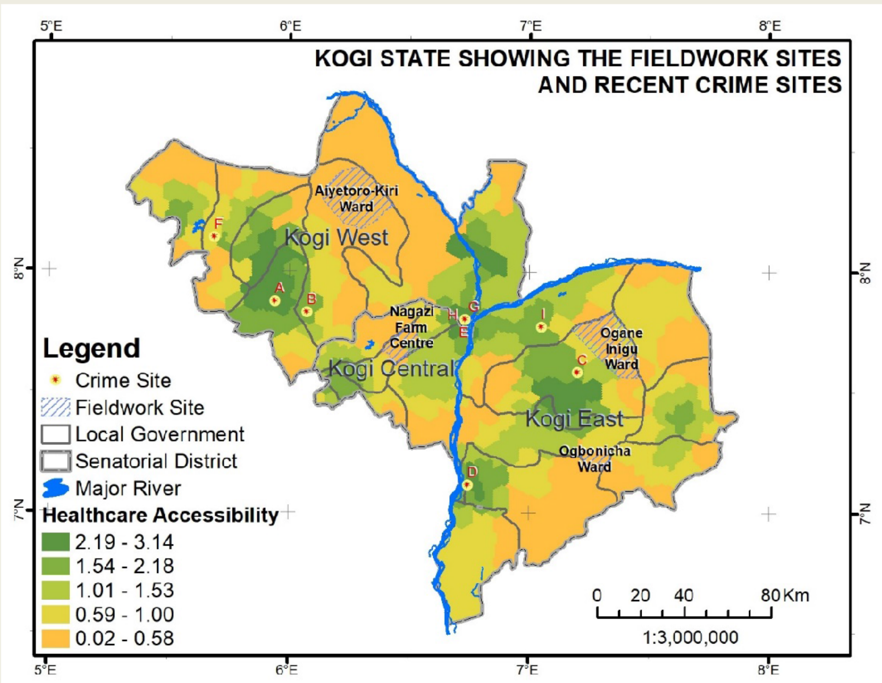
Date	From (country & city)	Flight Number	To (country & city)
26/04/2018	Abuja, Nigeria	AF 0818	Paris, France
27/04/2018	Paris, France	AF 1058	Newcastle, UK

Field Location(s)

Location:	Select wards with poor healthcare accessibility in Kogi State, Nigeria, are the sites for my fieldwork. The wards are: Ogane Inigu, Ogbonicha, Aiyetoro-Kiri, and Nagazi Farm Centre.

This map shows the specific locations of my fieldwork sites. It also depicts the locations of crimes recorded in the study area, Kogi State, in the last 6 months (i.e. since 1st May 2018) as documented on the Control Risks website, www.controlrisks.com.

The details of each of these mapped crime cases is attached in Appendix I



Risk Assessment

Does this travel and activity present a significant risk to safety?

Yes ☐ No ☒

(You must still identify all relevant hazards & risks below, even if you tick 'No'. Common hazards are suggested below, but add additional hazards if needed)

When carrying out the risk assessment the following hyperlinks will provide useful information:

- Occupational Health and Safety Service- University policy, guidance and risk assessment form
- UK Government Foreign and Commonwealth Office (FCO)- country specific travel advice
- Control Risks- a more detailed travel advice service purchased by Newcastle University (staff only)
- UK Government - Travel Health Pro- country specific advice on all aspects of health and vaccinations
- Refer to the GPS Field Safety Guide and the GPS Researcher Handbook for information on common fieldwork hazards in Physical and Social Sciences http://www.ncl.ac.uk/gps/internal/safety.html

What are the hazards (bold text)/ risks (bullet points)?	What controls have you put in place?
Accommodation • Physical defects • Risk of fire • Risk of robbery, physical or sexual assault • Terrorist incident e.g. bomb • Falls from balcony's	• I will lodge in standard and secure hotels in my study sites. I am very familiar with the study area; therefore I am confident about the safety of the hotels I will be lodging in. • I will be vigilant when registering at my hotel especially if the area is crowded. • I will ensure my room number remains confidential. • I will use the safe (if provided) in my room for valuables. • I will use the key chain, deadlock, spyhole and any other safety devices if receiving visitors. I will conduct meetings in the lobby or other public space. • I will make sure I know the location of fire exit routes and know what to do if an alarm is activated.
Work activity • Risks from work activities including fieldwork e.g. ○ Illness/ diseases ○ Lone working ○ Hazardous equipment ○ Transporting heavy samples/ equipment	• I will always be in the company of a research assistant when visiting study sites and participants. • I will take antimalarial and other relevant vaccinations before travelling, as well as avoid all forms of exposure to disease causing vectors in the study area. • I will never be on the field alone, being always accompanied by research assistant(s) that are familiar with the various sites. • As required with fieldworks in Nigeria, I will take permission from the local chiefs or community heads before commencing any fieldwork activity in the target localities.
Travel and transportation • Risk of theft/ attack during transfers to and from airport and on public transport • Accident whilst self-driving • Incorrect driving license • Hiring a vehicle and driver • Poor road infrastructure • Density of traffic • Poor driving standards • Poorly maintained vehicles	• Before commencing my PhD at Newcastle, I was a geography lecturer at the university in the study area, Kogi State University, Anyigba. Consequently, I have been engaged in conducting many fieldwork activities in various localities in the study area. The university's 4 x 4 vehicle was used to access remote field sites during such field trips. However, during my fieldwork, a 4 x 4 vehicle will be hired whenever I need to visit remote localities. This comes with a professional driver. • The public transport system in the study area as well as the road infrastructure are not in good shape; therefore, I will hire appropriate well maintained cars for my routine transportation in Nigeria. • I will avoid being a lone researcher/traveller by always being in company of a research assistant when visiting my study sites. • I will ensure that all my fieldwork activities (i.e. the focus group discussions) are organized during the day, such that travel to and fro my study sites will be during day light hours.

What are the hazards (bold text)/ risks (bullet points)?	What controls have you put in place?
• Lack of emergency services	
Location and or regional factors • Crime- risk of robbery/ physical or sexual assault • Terrorism or kidnap • Political instability • Remote working • Poor communications • Religious tensions • Cultural misunderstandings e.g. clothing, alcohol or behaviour • Natural disasters e.g. floods/ cyclones/ earthquakes	• On my previous employment in the study area, I was engaged in organizing many fieldwork activities. Therefore, I am very familiar with the study area. I will be dressed like the natives of the study area, such that I am very unlikely to be a target of any form of aggression/assault. • I have reviewed the UK Government's Foreign and Commonwealth Travel advice and signed up for e-mail travel alerts and downloaded the Control Risks app onto my smartphone in preparation for my fieldwork. • I know the basic geography of my study area and I am familiar with key routes. • I will follow local news report and be alert to developments that might trigger civil unrest. • I will take precautions against petty crimes including: ○ Keeping valuables and passport safe especially in tourist locations or other public places. I will ensure I keep a colour copy of my passport separately. ○ Keeping my credit card in sight ○ Using ATM's in secure locations e.g. hotel lobby. ○ Being aware of people around me when using ATM's ○ Keeping my bag close to my body to avoid bag snatching • In the unlikely event of a confrontation, I will surrender items to the aggressor. • I will always carry a working mobile phone pre-programmed with important numbers. • I will follow the Stay Safe guidance in the event of a terrorist incident. I will be vigilant, monitor local media and follow the advice of the local authorities. • I will only carry enough cash for the day. • I will be alert to my surroundings.
General health/ environmental factors • Extreme weather • Food and drink (poor hygiene) • Infectious diseases (some requiring vaccinations) • Biting insects or animals including risk from rabies & malaria • Poor or distant medical facilities • Sexually transmitted diseases	• I am familiar with the weather and foods in Nigeria because I have lived there for most of my life. • I will follow country specific health advice from UK Governments Travelhealthpro website for Nigeria. • I will follow the FCO Safety and Security Advise at https://www.gov.uk/foreign-travel-advice/nigeria/safety-and-security. I have subscribed to the FCO Travel advice email alerts. • Serious tropical illnesses like malaria, typhoid, Lassa fever, dengue fever and yellow fever occur in Nigeria: I will avoid mosquito bites particularly between dawn and dusk, by using long-lasting insecticide-treated mosquito nets, anti-mosquito insecticides and anti-malarial pills. I have also taken vaccines for these health risks. • There is a risk of insect or tick-borne diseases in some areas of West Africa. This includes diseases such as African Trypanosomiasis (sleeping sickness), African tick bite fever, chikungunya, Crimean-Congo haemorrhagic fever, leishmaniasis, Rift Valley fever and West Nile virus. I will avoid insect and tick bites day and night by wearing trousers and long sleeve clothes and using insecticides. • I have consulted my GP and will take necessary anti-malaria drugs during my fieldwork. • I have started taking the essential immunizations recommended for traveling to Nigeria, as outlined on the 'fit for travel' website https://www.fitfortravel.nhs.uk/destinations/africa/nigeria. This includes vaccines for Hepatitis B, Meningococcal Meningitis, Rabies and Typhoid. I will consult my family's physician in Nigeria if I need further medical attention while doing my fieldwork. My parents reside in the study area, Kogi State.

What are the hazards (bold text)/ risks (bullet points)?	What controls have you put in place?
	• Schistosomiasis: I will avoid wading, swimming, or bathing in freshwater where possible. Swimming in chlorinated water or sea water is not a risk for schistosomiasis. • I am native to the study area wherein I lived for about 30 years before commencing my research programme at Newcastle. By July 2018, I also spent a 1 month holiday in the study area. I have undertaken many fieldwork activities in Kogi State (and elsewhere in Nigeria) in times past, so I am very experienced at this. Newcastle University's comprehensive insurance policy with Chubb insurance is adequate for this journey. I do not need additional travel and medical insurance in order to travel to Nigeria for this fieldwork.
Individual factors • Level of cultural awareness • Inability to speak Language • Cultural/ religious or sexual orientation • Pre-existing medical conditions or mental health conditions requiring management	• Being a Nigerian, I am aware of the cultural diversity of my study area which is also my state of origin. I am native to the study area, my parents are resident in the study area. • I understand and speak some of the local languages in the study area, but I will always be accompanied by reliable indigenes of localities wherein my fieldwork is conducted. • I lived in the study area, Kogi State, for about 30 years before commencing my PhD programme at Newcastle. Furthermore, from 2009 to 2016, I worked as a geography lecturer with the university in the study area, Kogi State University, Anyigba. On this role, I undertook many fieldwork activities in various localities in Kogi State (and elsewhere in Nigeria); therefore, I am very experienced at this.
Specific FCO advice (overseas travel only) • Threat of criminal kidnap • Risk of Zika virus • Large crowds and public demonstrations could quickly turn violent • Terrorism	• Criminal kidnap is not pervasive in Kogi State. I am aware of the particular places of high kidnap risk in Kogi State, and I have no need to visit such places for my planned fieldwork. • When going to my specific fieldwork sites, I will travel with security. I have already made adequate security arrangements for my fieldwork activities in Nigeria. I will also be accompanied by trustworthy natives of the various localities I will be visiting, some of whom will serve as interpreters and/or field assistants. • I have read the information and advice about the risks associated with Zika virus, provided on the National Travel Health Network and Centre website. There is however no risk of Zika Virus in my study area, Kogi State. • I will be aware of my surroundings and avoid large crowds and public demonstrations and vary routines. • I will follow news reports and be alert to developments. If I become aware of any nearby unrest or disturbances, I will leave the area immediately. • I will avoid places where crowds gather, including religious gatherings and places of worship, markets, shopping malls, hotels, bars, restaurants, transport hubs and camps for displaced people. Most of my stay will be in Kogi State, this has no record of and is not prone to terrorism.

Emergency Procedures (You need an emergency plan even if you are undertaking UK based fieldwork)
My communication protocol is provided in Appendix II. I will keep in contact with my research supervisors all through my stay abroad. My friend in Nigeria, Dr Francis Atanu, will also be aware of my itinerary while in Nigeria. Francis will not be on the field with me, but will be in communication with me throughout. In the unlikely event that my supervisors do not hear from myself, they should contact Francis. If they are unable to hear from both myself and Francis, they can then notify Chubb Insurers.

Approval

Traveller

Assessor name (Person who filled out the form)**:**	Eleojo Abubakar	Signature:		Date:	12/12/2018

Authorised by (line manager, supervising academic, PVC)

Supervisor name:	Dr Alison Copeland	Signature:		Date:	06/01/19

PVC		Signature:		Date:	

The completed risk assessment form should be e-mailed to: gps.safetyofficers@newcastle.ac.uk , to be reviewed.

Appendix I

Map Code	Crime Date	Crime Details
A	14-May-18	In Ijumu, Kogi state, Fulani herdsmen attacked two Tiv communities, killing 10 people and destroying property.
B	15-May-18	In Kabba, Kogi state, Fulani herdsmen shot dead a forestry operator
C	31-May-18	In Anyigba, Dekina, Kogi state, six people were reportedly killed in alleged cult violence; soldiers were subsequently deployed to the area
D	17-Jul-18	In Idah, Kogi state, unidentified gunmen assassinated the Director of Works, at the Federal Polytechnic, at his residence
E	18-Jul-18	In Lokoja, Kogi state, two girl schools due for commissioning were reportedly vandalized and set on fire by unidentified attackers.
F	19-Jul-18	In Yagba, Kogi state, gunmen dressed in military uniforms opened fire at the Senator Dino Melaye's convoy, while on his way from inaugurating several projects.
G	11-Aug-18	In Ugwan Pawa, Lokoja, Kogi state, two people were killed in separate incidents during by-elections to fill the vacant Lokoja /Kogi seat in the House of Representatives.
H	08-Sep-18	In Lokoja, Kogi state, clashes broke out among PDP supporters at the PDP secretariat over a dispute concerning delegation lists; the police intervened and injuries were reported.
I	08-Oct-18	In Bassa, Kogi state, Bassa Kwomu and Egbura Mozum clans reportedly fought, leaving 17 dead.

Appendix II Communication Protocol

This form should be attached and read in conjunction with the travel risk assessment for an individual trip on University business. It details the agreed arrangements for contacting traveller(s).

Traveller Name: Eleojo Abubakar

My active Mobile Number in Nigeria: +234 (0) 8056894358
Personal Email: info4ele@yahoo.com
Skype user id: eleojo101

Communication to be made:

[X] As soon as reasonably possible after arrival at accommodation and

[X] At 3 day(s) intervals thereafter and

[X] As soon as reasonably possible on arrival back in UK

Delete boxes above if not applicable having regard to the destination country and risk profile of the trip

Agreed Communication Methods

[X] Telephone (landline or mobile) [X] SMS text [X] E-mail (University and personal) [X] Skype

[X] Other (Contact my friend, Dr Francis O. Atanu, on +2348064310495 and/or atanufo@gmail.com)

University Contacts

Please enter below the names and full telephone numbers (including international dial) of the person(s) who the traveller will contact.

Name	Relationship to Traveller	Telephone/ e-mail
Dr Alison Copeland	PhD Research Supervisor	+44 (0) 7963892716

Action in the Event of None Contact with Traveller

The above named persons are responsible for taking action in the event that a traveller does not make contact as agreed with this protocol.

Stage 1
Attempt to contact the traveller using all the means of communication available e.g. mobile, text and e-mail. Allow a reasonable time* for the traveller to respond.

Stage 2
Contact the traveler's friend in Nigeria, Dr Francis O. Atanu, using all the provided means of communication. Allow a reasonable time* for the traveller's friend to respond. Francis mobile number is +2348064310495.

Stage 3
Repeat steps 1 and 2, and leave a reasonable time* for the traveller to respond.

Stage 4
Notify the University's Insurance Team for advice (within normal hours) or contact our Chubb Insurers 24 hour helpline on +44 (0) 207 895 3364. You will need a copy of the risk assessment including traveller contact details and a full itinerary before you contact Chubb.

*reasonable time will vary having regard to the itinerary of the traveller, level of risk and the general state of the communication infrastructure in the country. For Nigeria and the nature of the traveller's fieldwork, this should be at least five days. Some fieldwork sites may not have a reliable mobile/internet network coverage.

C.2 Ethical Considerations for Qualitative Fieldwork

C.2.1 Participant Consent and Debriefing

The researcher or field assistant provided a written summary of the research project to each participant (on an information sheet) before seeking their consent. Where a participant was unable to read in the English Language, the researcher (or field assistant) translated or interpreted the written summary to the participant's native language. Participants were requested to provide written informed consent by filling-in and signing the consent form provided for this study. No incentive was provided to the participants except an assurance that the findings of this research would be brought to the notice of relevant stakeholders in the health sector, which could help to enhance the physical accessibility of healthcare services in their locality. Please see the accompanying information sheet in Appendix C.3.

After prospective participants had read the provided summary of the study (contained on the information sheet) and accepted to contribute on the study, the researcher gave each participant a consent form with which to provide written consent to take part in the study. Participants formally gave their consent by ticking relevant boxes, filling-in relevant spaces and appending their signatures on the consent forms provided. Please see the accompanying consent form in Appendix C.4.

Participants were debriefed immediately after completing the group discussions. A debriefing sheet was given to each participant containing relevant information. As part of this process, participants were verbally assured that the data collected from the group discussions would be stored securely and used only in ways that will not constitute any form of harm, disadvantage, or distress to participants. This includes ensuring that the identities of participants are confidential in any publication in which the data collected is used. In addition, the contact of the researcher was given to every participant so that they can raise possible questions or concerns during the lifespan of this project. Please see the accompanying debriefing form in Appendix C.6.

C.2.2 Potential Risk to Participants and Risk Management Procedures

This qualitative study elicits relevant information on the match between the needs and utilization of essential healthcare services and the availability and proximity of the services with a view to accounting for patients' ability to benefit from extant and/or potential PHC services in the study area. Research respondents were asked about the extent to which their healthcare needs were being met as well as on their barriers to utilizing necessary healthcare. These questions could cause some psychological discomfort in the form of reminding some participants of their difficulties in obtaining the needed care. Furthermore, seeking medical attention for oneself or another could be associated with traumatic memory. Nevertheless, participants were assured that the findings of this study would be brought to the notice of relevant public authorities. Therefore, they were hopeful that this study could result in the amelioration of their healthcare difficulties. Consequently, this study was received in a positive light.

C.2.3 Primary Data Management and Confidentiality

Research data were collected as recordings from group discussion sessions and then as resulting transcripts. These were held as digital files stored on secured storage devices and personal computers. The project information sheet and debriefing form (in Appendix C.3 and C.6, respectively) contain relevant information on the protection of participants' confidentiality and other relevant considerations. To reiterate these, data from group discussions were securely stored in accordance with the UK Data Protection Act (2018), the General Data Protection Regulation (GDPR) and relevant policies of Newcastle University. The personal details of participants (contained in monitoring and consent forms) were stored separately from the transcripts of the group discussions produced from the various focus groups. This made it very unlikely for unauthorized third parties to be able to gain access to the full research data.

Only the researcher and his supervision team had access to the project data. All personal information was anonymized before publishing research results. On completing this study, the focus group data will be stored securely for 5 years, in accordance with primary data management policies of Newcastle University, after which they will be destroyed.

C.2.4 Institutional Ethical Approval for Fieldwork: The Feedback

Ethical Approval

Dear Eleojo

Thank you for your application for ethical approval of your project "The socio-spatial coverage and inequality of healthcare services in Nigeria". I confirm that Dr Simon Woods has approved it on behalf of the Faculty of Humanities and Social Sciences Ethics Committee.

Please note that this approval applies to the project protocol as stated in your application - if any amendments are made to this during the course of the project, please submit the revisions to the Ethics Committee in order for them to be reviewed and approved.

Kind regards,

Wendy

Wendy Davison
PA to Professor Matthew Grenby, Dean of Research and Innovation
and Mrs Lorna Taylor, Faculty Research Manager
Faculty of Humanities and Social Sciences
Great North House
Sandyford Road
Newcastle upon Tyne, NE1 8ND
https://goo.gl/maps/2K6SeRCuVY42

Telephone: 0191 208 6349
Email: Wendy.Davison@ncl.ac.uk

C.3 Fieldwork Information Sheet

Professor W Maloney
Head of School

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Newcastle University
Ground Floor, Daysh Building
Newcastle upon Tyne
NE1 7RU United Kingdom

FIELDWORK INFORMATION SHEET 27th November, 2018

RESEARCH THEME: BARRIERS TO HEALTHCARE UTILIZATION IN KOGI STATE, NIGERIA

I am Eleojo Abubakar, a doctoral student of Geography, at the School of Geography, Politics and Sociology (GPS), Newcastle University, UK. I am interested in ensuring that sufficient healthcare services are provided in close proximity to needy populations. My preliminary analysis suggests that there is a shortage of essential healthcare services in your locality that is why I have come here to conduct some group discussions. This will enable me gain a better understanding of your situation and then make appropriate recommendations in my study. This is part of my doctoral research aimed at explaining social and economic differences in people's ability to meet their healthcare needs.

Poor people usually have more healthcare needs than affluent people. For economic reasons, there is often a limited supply of healthcare facilities to poor localities. Therefore, available healthcare facilities are often located far away from the people with the most healthcare needs. If healthcare facilities are located in places where they are needed, more people will be able to reach them in time. People that can easily reach needed healthcare services are likely to use them more regularly than people that experience difficulties in reaching their needed healthcare services. When needed healthcare services are used regularly, the overall health of a population will improve. Because of the observed shortage of essential healthcare services in your locality, not many people will be able to regularly obtain needed healthcare services due to the difficulties they are likely to experience in reaching the locations of available healthcare facilities. This will limit the timely uptake of needed healthcare, thereby causing negative effects on the overall health of people in your community.

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As part of my research, I am suggesting that a new healthcare facility be sited in your locality. However, to fully justify this suggestion, I need to find out about other cultural, religious or economic factors that may influence your ability to utilize available or proposed healthcare facilities. I also like to know of any attributes that you expect healthcare facilities to possess in order for them to be very acceptable to you. This information will guide government authorities in ensuring that planned healthcare facilities are located in places where they are most needed. It will further ensure that the attributes of proposed healthcare facilities match the cultural, religious and economic expectations of your community. With this information, relevant government authorities will be convinced that healthcare investments in your community will be very beneficial to you, and not be a waste.

To this end, I would like to invite you to participate in a group discussion on my research. In this focus group, you will have the opportunity to discuss your experiences in reaching and using healthcare facilities when you have needed them. You will also have the opportunity to tell me your opinion and expectations of the healthcare facility I am proposing for your locality. From these conversations, I intend to understand the influence that your social, economic, and cultural attributes may have on your ability to reach and obtain the healthcare services that you need. The group discussion will comprise 6 – 8 participants and last for about 45 minutes. This will take place in any available public venue that is safe, such as a village/community square or a town hall.

Before the group discussion starts, I will collect some information about you using a monitoring form that contains questionnaire-type questions. Your answers to those questions will help me gain a better understanding of the influence that your personal attributes may have on your healthcare experiences and opinions. I also request that you kindly provide me with a written confirmation (in research this is known as consent) that you have voluntarily agreed to contribute to my research as participant. Please do this by filling and signing the consent form for this study. Please note that you are free to withdraw your participation from this study at any point, even if you have signed the consent form. Please also note that there will be no negative consequences whatsoever for you or anybody else in your family if you decide not to take part or withdraw from this study.

I will store all your personal data and data from our group discussion confidentially and securely in accordance with the UK Data Protection Act (2018), the UK General Data Protection Regulation (GDPR) (2018) and other relevant guidelines of Newcastle University. This means research data that are on paper will be stored in my office file cabinets and/or drawers with locks. Research data that are in digital form will be stored in my computers and/or digital storage devices with passwords. Only myself and my supervision team will have access to the project data. After all your personal information have been rendered unidentifiable, parts of the transcripts from our group discussion will be used in my doctoral dissertation as well as in other scholarly and non-scholarly publications and presentations. On completing this study, the research data will be stored securely for 5 years, after which they will be destroyed.

Thank you for considering taking part in this study. Please do not hesitate to contact me if you have course to raise any questions or issues concerning this study.

Yours Sincerely

Eleojo Abubakar

Doctoral Candidate, Human Geography
School of Geography, Politics and Sociology (GPS)
Newcastle University, UK
Email: e.o.abubakar2@ncl.ac.uk

C.4 Consent Form for Study Participants

Professor W Maloney
Head of School

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BARRIERS TO HEALTHCARE UTILIZATION IN KOGI STATE, NIGERIA

CONSENT FORM FOR STUDY PARTICIPANTS *(Please tick where appropriate)*

☐ I confirm that I have read and understood the accompanying information sheet (or the information sheet has been read to me) for the above research project. I have been informed of the aims, methods and duration of the study, and the role I will play in this.

☐ I understand that my participation is voluntary and that I am free to change my mind at any time and withdraw from the study without giving a reason.

☐ I understand that the data I have provided for this study may be published, after it has been anonymized and rendered unidentifiable.

☐ **I agree to take part in this study.**

Participant Declaration

I have read and understood this consent form and had a chance to ask questions concerning any areas which I felt needed further clarifications. The data elicitation, storage and processing arrangements have been explained to me and by signing this form I agree to these arrangements. I have been informed about the types of data, including personal data that the researcher will elicit from me and for which purposes these data will be used. The lawful basis for processing my personal data is consent.

Signed: ______________________________ Date: ________________________

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Contact Details of Participant

The following information will not be used to identify you in the research but will only be used when making focus group arrangements and/or for any necessary follow-ups. It is not necessary for you to provide your real name or full name if you prefer not to do so:

Full Name: ………………………………………………………………………………………

Telephone Number: ………………………………………………………………………

Email: ………………………………………………………………………………………………

Contact Details of Researcher

In the event that you wish or need to contact me, please do not hesitate to do so using any of the following means:

Postal Address:

Eleojo Abubakar

School of Geography Politics and Sociology

3rd Floor, Northumberland House,

Newcastle University.

NE1 7RU, United Kingdom

Email: e.o.abubakar2@ncl.ac.uk

Phone numbers: +234(0)8056894358 or +44(0)7917138815

C.5 Participants' Monitoring Form

Professor W Maloney
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FIELDWORK MONITORING FORM

5th November, 2018

RESEARCH THEME: BARRIERS TO HEALTHCARE UTILIZATION IN KOGI STATE, NIGERIA

'Equity-stratifiers' is the internationally adopted data disaggregation framework for studying health(care) inequalities (Gwatkin, 2007; Commission on the Social Determinants of Health, 2008; World Health Organization, 2013). It is denoted by the acronym 'PROGRESS', which stands for Place of Residence, Race/Ethnicity, Occupation, Gender, Religion, Education, Socioeconomic Status and Social Capital. In this form, many of these attributes are collected to aid the analyses of the focus group data for this study.

It is helpful to this study that answers are provided to all the following questions; however, it is not compulsory to answer any question you may feel uncomfortable with. Please answer the following questions, by ticking the boxes or filling the spaces provided:

1. Gender:

Female		Male	

2. Age (years):

20 - 24		30 - 34		40 - 49		55 - 59		65 - 69	
25 - 29		35 - 39		50 - 54		60 - 64		70 and older	

3. Place of Residence:
   a. Community Name: ....
   b. Ward Name: ....
   c. Local Government Area: ....

4. Ethnicity:

Bassa		Hausa/Fulani		Ibira		Sayawa	
Igala		Yoruba/Kabba/Okun		Igbo		Others	

5. Religion:

African Traditional Religion		Christianity		Islam		None	

6. Are you literate?

Yes		No	

7. If your answer to question 6 above is yes, what is your highest educational qualification?

First School Leaving Certificate		Secondary School Certificate		National Certificate in Education (NCE)		Ordinary National Diploma (OND)	
Higher National Diploma (HND)		First Degree (BSc, BA, B.Tech)		Postgrad Degree (MSc, PhD etc)		None	

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8. Occupation (if any): ……………………………………………………………………………………

9. Average monthly income range from all sources (₦):

Less than 25,000		50,001 – 75,000		75,001 – 100,000		Over 100,000	
25,001 – 50,000							

REFERENCES

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WORLD HEALTH ORGANIZATION (WHO) 2013. *Handbook on health inequality monitoring: with a special focus on low- and middle-income countries*. Geneva: World Health Organization. Online at: http://apps.who.int/iris/bitstream/10665/85345/1/9789241548632_eng.pdf

C.6 Participants' Debriefing Sheet

Professor W Maloney
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FIELDWORK DEBRIEFING SHEET

5th November, 2018

RESEARCH THEME: BARRIERS TO HEALTHCARE UTILIZATION IN KOGI STATE, NIGERIA

Thank you so much for contributing to my research as a participant in a focus group discussion. You are already aware of the goals of my research. As an academic researcher, I am interested in ensuring that there is sufficient healthcare services in every community. I discovered that there is a shortage of essential healthcare facilities in your locality that is why I came here to conduct a focus group discussion. The focus group discussion was meant to inform me of your experiences in obtaining needed healthcare services from the facilities within your reach.

In order to improve your experiences in obtaining needed healthcare services, my preliminary research has suggested that a new healthcare facility is needed in your locality. Therefore, I was also interested in knowing what attributes you expect of a new healthcare facility, so that it is able to meet your healthcare needs in an acceptable manner. These information will assure healthcare providers that locating a new healthcare facility in your locality will be very beneficial to you and not be a wasted effort.

I have taken note of the experiences and concerns you have shared regarding your ability to obtain needed healthcare services. I can assure you that I will let relevant government authorities know about these. I am hopeful that this will greatly motivate government authorities and other healthcare providers to build an appropriate healthcare facility in your locality, in line with my recommendations.

I can also assure you that your names will not be mentioned in my write-ups and all the information you have given me will be kept confidential. If you have any questions or concerns about this research, please do not hesitate to let me know about these by phone or email. My phone number is 08056894358 and my email address is e.o.abubakar2@ncl.ac.uk. I do not expect that this research would have caused you any form of psychological distress. However, if this happens, please seek help from a competent counselor.

Eleojo Abubakar

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C.7 Modalities of Focus Group Discussions (FGD)

C.7.1 Background to FGDs

This research project considers neighbourhood (or locality or place) accessibility to healthcare services in contrast to individual/personal accessibility; therefore, the focus group participants are encouraged to share their personal experiences as well as the experiences of neighbours/friends (or other members of their community) that they may be aware of. In so doing, this study incorporates the experiences (and potential opinions and perceptions) of persons that are not physical participants in the group discussions.

Inter-participant interactions are also encouraged, either by agreeing with and supporting the opinion expressed by other participants or disagreeing with (and contradicting) the opinions expressed by other participants.

The factors to consider in the recruitment of participants for this study are explained in Sections 2 and 3 below, while in section 4 are the specific themes and questions that each focus group discussion will cover.

C.7.2 Procedure for Recruiting Group Participants

In each of the target community/locality, the researcher (and/or his assistants) will obtain the necessary permission from relevant local authorities and/or gatekeepers. This could be the village chiefs or community heads or local vigilantes. These gatekeepers will also assist the fieldworker in arranging a suitable venue for the FGDs and other logistics. Such venues could be a village square, the classroom of a public primary/secondary school, or any other convenient and safe place. Thereafter, potential participants for this study will be contacted and recruited following the demographic specifications of Section 3 below. In recruiting participants, the content of the information sheet (as well as the specific questions in Section 4 of this guide) will be explained to each potential participant. Each willing participant will also be given a copy of these documents. At the time of recruitment, consenting participants will be requested to fill in the consent form and monitoring form for this study. In addition to the other information requested on the monitoring form, the contact details of interested participants (especially their phone numbers) will be collected so that the researcher can stay in touch with the participants. At the time of recruitment, participants will also be told the date and venue for the fieldwork.

In each locality of interest, efforts will be made to recruit more participants than necessary (of about 10 to 12 persons), such that should some participants fail to turn up, a sufficient number of participants will be available for the group discussions.

C.7.3 Demographic Composition of the Focus Groups.

Each focus group will comprise 6 – 8 persons. In recruiting participants for each focus group, the following demographic factors will be considered:

1. **Age:** The composition of each focus group will be persons of similar age groups. Overall the research participants which persons whose ages are between 20 and 49 years old. Even though the secondary data feature age groupings of five years, that is 20 – 24, 25 – 29, 30 – 34, up to 45 – 49; for practicality reasons, this level of fidelity in age groupings will be difficult to achieve in the composition of each focus group. Therefore, a 10-year interval will be used in the recruitment of the focus group participants. This implies that the participants for a specific focus group can be persons whose age group is 20 – 29 or 30 – 39 or 40 – 49 years old. For cultural reasons in Nigeria, stark age differences mean that the voices of much younger persons are likely to be suppressed in discussions involving older persons. Across the various focus groups, different age groups will be targeted such that the overall age range of the participants of this study will be covered. That is, while one focus group targets participants of a certain age group, another focus group will target participants of a different age group.
2. **Socioeconomic Status or Income:** Each focus group will comprise of persons of similar socio-economic status. Well-off members of society are likely to be more outspoken and dominate discussions within less privileged participants are involved. The target participants for most focus groups will be deprived individuals.
3. **Education or Literacy:** The educational or literacy level of participants comprising each focus group will be similar. Thus, it is easy for participants to interact with each other on a similar level of reasoning.
4. **Religion and Ethnicity:** Participants in each focus group can come from various religions and ethnic backgrounds, providing they understand the same language.
5. **Gender**: Each focus group will comprise a near-equal mix of male and female participants. The facilitator will ensure that no gender dominates the discussions.

6. **Marital Status**: Participants in each focus group can comprise persons of various marital status. Efforts will be made to understand the effects of variations in marital status on participants' perceived healthcare needs and healthcare accessibility.

C.7.4 Other Considerations

The documentations approved for this fieldwork, such as the ethical approval and risk assessment forms, detail other planned modalities for this fieldwork. The information sheet, consent form and monitoring form for this research, will be given to each participant (and where required, filled-in) before each group discussion begins. The debriefing form will be given to the study participants after the completion of each group discussion.

C.7.5 Research Themes to Cover

All relevant fieldwork documentation, especially the consent form and monitoring form, will be completed before commencing the group discussions. Audio recording devices will also be turned on.

In discussing the various themes of this study, participants are encouraged to use short narratives, illustrations and stories that are relevant. Every member of the group is encouraged to express their opinion. **The FGD facilitator will prompt for discussions using the following background information and questions:**

Background: People are likely to seek healthcare services for various reasons. These include: to prevent diseases/ailments (such as vaccinations), ensure safety in (or manage) potentially risky health-related situations (such as childbirth and antenatal care), or to treat various types of diseases/sicknesses when they occur (such as malaria, skin diseases, sexually transmitted diseases, typhoid fever etc).

1. What specific types of healthcare services (i.e. specific ailments) do you often need? You can mention as many health conditions that yourself, your family or community suffer from.
   a. How regularly do you have these healthcare needs?
   b. To what extent are these needs being met in your locality? In other words, how satisfied are you with the healthcare services available in your community?
   c. Do you usually experience any practical difficulties or challenges in meeting your identified healthcare needs? If so, explain these difficulties?

d. In your opinion, what can be done to enable you to better meet these needs? (you may see Question 5 for some ideas)

Background: In Kogi State, there are different types of healthcare services, such as formal/western healthcare providers (like hospitals, clinics, or pharmacies), traditional or alternative medical providers (such as herbalists or native doctors) and prayer houses.

2. What types of healthcare facilities do you often use and why? Participants can mention more than one healthcare types.

a. Under what conditions (or ailment types as specified in Question 1) are these healthcare types sought? In other words, what socioeconomic or demographic or health factors inform your choice and/or decision of healthcare facility types to utilize?

b. What are your experiences (both positive and negative) in accessing the different healthcare facility types that you usually use? (you may see Question 3 for some ideas)

c. What can be done to improve these experiences? (you may refer to the background to Question 6 below)

Background: Based on their ownership or management type, formal healthcare providers can be classified as public (or government) owned, private, community-owned, or faith-based.

3. Whenever you are ill and/or need medical attention, if you decide to visit a formal/western healthcare provider, what type(s) of facility do you prefer and why?

Background: Whenever you visit a healthcare facility, your experience may be influenced by any or a combination of the following factors: cost of services, friendliness/attitude of the medical staff, quality of services received, waiting time before being attended to, travel distance/time to your preferred facility, mode of transportation, language and cultural factors, religion etc.

a. The last time you visited your preferred facility, could you discuss your experience with us?

b. If any of these experiences were unpleasant/unsatisfactory to you, what types/forms of improvements do you desire?

4. Have there been times you have been ill and needed medical attention and for some reason, you could not obtain your desired healthcare? If so, describe some of such experiences?

   a. What factors limited you? (You may see question 3 for an idea)

   b. What can be done to remove these limitations/barriers?

5. Would building (or upgrading/renovating) a healthcare facility in your locality encourage you to regularly utilize western healthcare facilities whenever you have a healthcare need?

   a. If this will not promote your regular healthcare utilization, why is this so?

Background: Depending on the types of limitations or challenges you experience in accessing the various types of healthcare services you often use, you may require assistance from various sources, such as your nuclear or extended family members, NGOs, faith-based organizations (like churches or mosques), charities or philanthropists, your local community/village development associations, the government (either local, state or federal) etc.

6. From which of these sources do you expect to receive help and why?

Background: In order to improve your ease and ability to meet your essential healthcare needs, there are various types of assistance or support that could be considered. Some examples include: the provision of financial aids and/or free medical services (even if they are not very close to your locality), siting/locating services in your locality, creating or enhancing access roads to neighbouring communities with healthcare services, helping you to relocate to places/towns (localities) with better access to healthcare services, providing you with personal mobility, the provision of a better public transport system in your locality, providing you with better employment (or sources of income), or facilitating/improving your current employment (such as agricultural subsidies, like fertilizers, seedlings, pesticides etc), other forms of assistance peculiar to you and/or your locality.

7. What type(s) of assistance do you prefer for your locality? In other words, which of the foregoing options are more important to you (or your locality) and why?